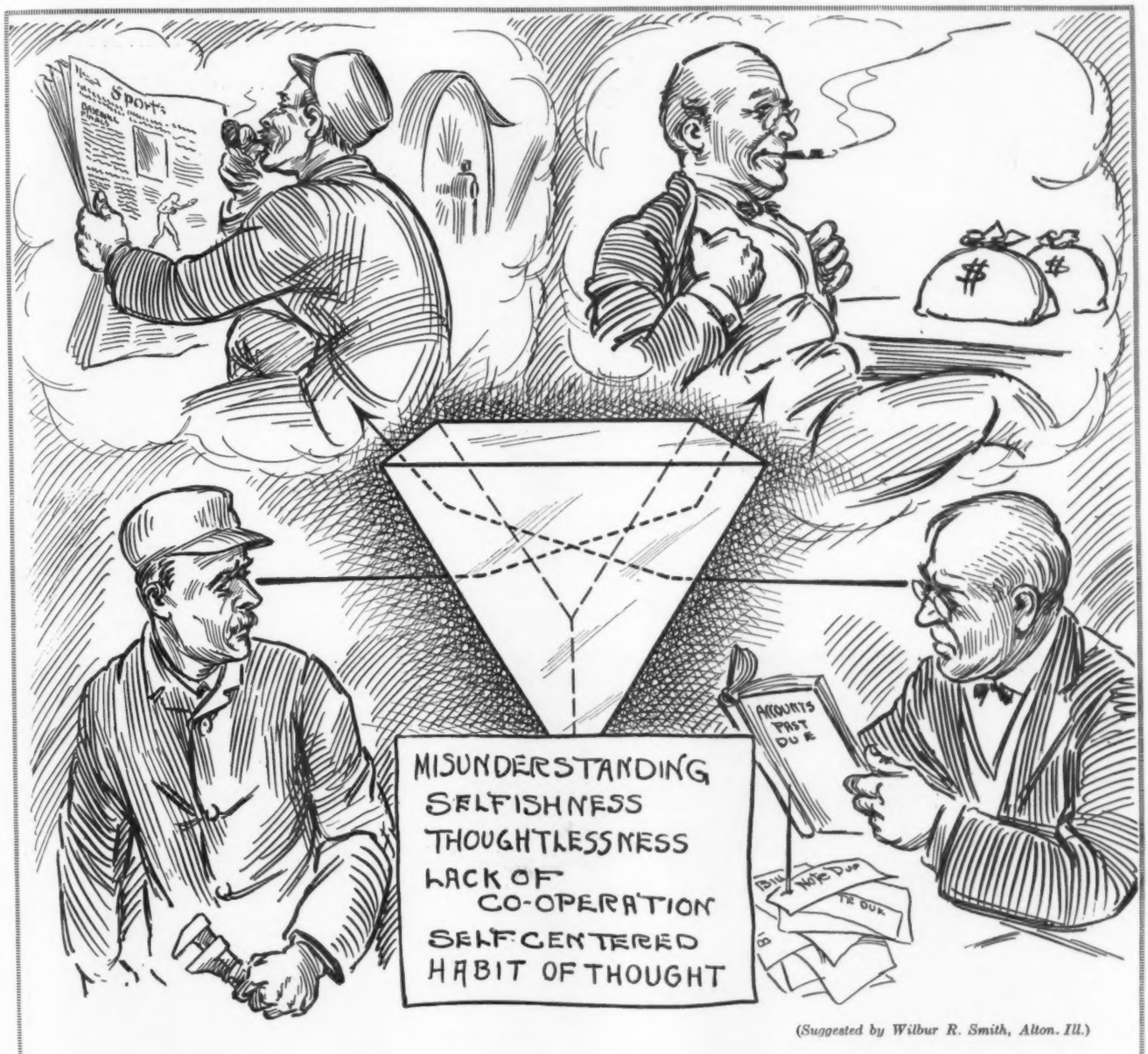
POWER

Vol. 41 NEW YORK, JUNE 15, 1915 No. 24



(Suggested by Wilbur R. Smith, Alton, Ill.)

The Prism That Refracts Our Vision

Boiler Plant of the Bessemer Coal and Coke Company

By Warren O. Rogers

SYNOPSIS—Six 72-in. return-tubular boilers are installed in pairs, with but one combustion chamber and one stoker for each pair. The fuel used is unsalable bone containing from 30 to 40 per cent. of noncombustible and averaging from 8000 to 11,000 B.t.u. per pound as fired.

A practice that will attract the attention of engineers is the burning of high-grade coal in the furnaces of coal-mining boiler plants. An instance where this is not done is at the power plant of the Bessemer Coal & Coke Co., Russellton, Penn., where a grade of fuel for which there is no market is burned with the aid of mechanical stokers, each feeding a common furnace for two return-tubular boilers.

The mines are about eighteen miles northeast of Pittsburgh, on the Bessemer & Lake Erie R.R. The main boiler plant consists of eight return-tubular boilers, 72 in. in diameter and 18 ft. long, each rated at 150 hp. Six are in one boiler house and two in another. The six were originally hand fired, the furnaces being supplied with steam jets to assist in the combustion. The other two were equipped with mechanical stokers supplemented by steam jets, with the idea of burning the bone which came from the mine. The arrangement did not prove satisfactory in operation, because of the high percentage of noncombustible in the fuel, so the furnaces were all burning the best slack and ¾-in. nut coal, worth $1 a ton at the mine.

Superintendent of Mines J. G. Bart believed that low-grade fuel could be burned if a properly designed stoker were installed. An unusual condition exists in this mine.

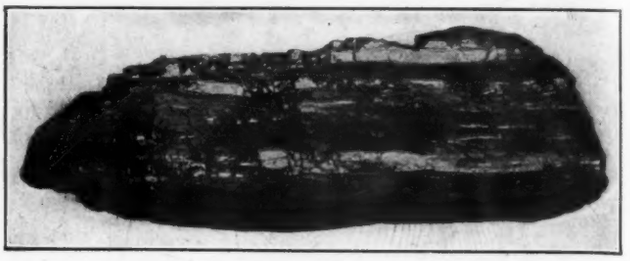


Fig. 2. Piece of Bone, the Bright Streaks Being Coal

There are two seams of coal about 3½ ft. thick and between them is a binder of bone composed of layers of slate and thin strata of coal. This is shown in Fig. 1. A piece of bone that was taken from a car of fuel is shown in Fig. 2 about one-half size. The bright streaks are the layers of coal, the dark portion being bone. Before the machine was put to work removing the bone, the latter was placed to one side by the miners and at convenient periods was hoisted to the surface and hauled away. The production was about 60 carloads a month,

Fig. 1. Cutting Machine Removing the Bone Binder from Between the Two Seams of Coal

and the cost of its removal, with an average haulage charge of about $6 a car, was not far from $360 a month, or $4320 a year. This bone has a heat value of between 8000 to 11,000 B.t.u. as delivered to the furnaces and an ash content of between 30 and 40 per cent.

To save the 100 tons of marketable coal that was burned each 24 hours under the eight boilers, to cut the cost of hauling away the bone and at the same time to reduce the boiler-room labor charges kept Superintendent Bart on the trail of a stoker that would fill the requirements.

About two years ago the work of installing a Taylor three-retort, underfeed stoker under each pair of boilers, or three stokers for the six boilers in the larger room, was

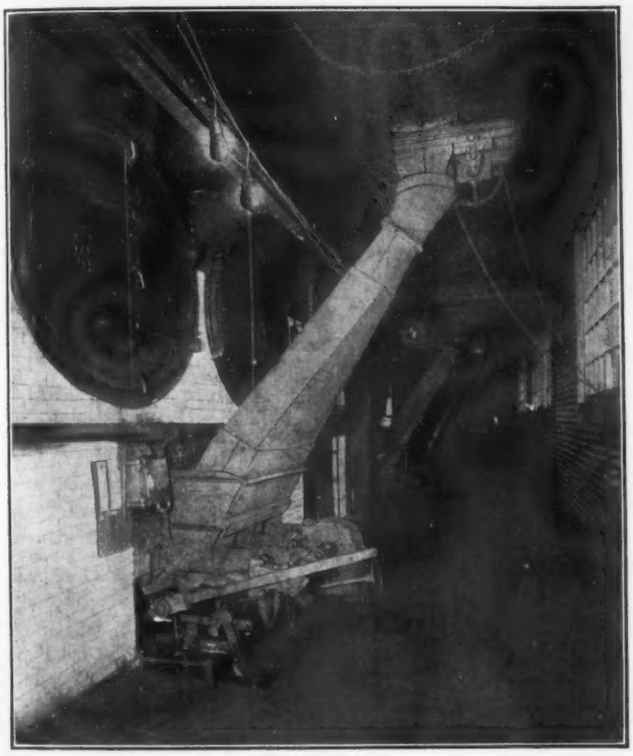


FIG. 3. A THREE-RETORT UNDERFEED STOKER SERVING TWO 72-IN. RETURN-TUBULAR BOILERS

begun. A single boiler would require a two-retort stoker and by placing two boilers over one three-retort stoker the initial cost was lessened and the efficiency was not reduced. Since the installing of the stokers, the boilers have been operated at 175 to 200 per cent. rating.

Fig. 3 is a view of the boiler room, showing the stokers placed with their center lines midway between the two boiler units. Fig. 4 shows the stokers from the rear end of the boiler setting.

The boilers are hung in pairs from steel railroad rails weighing 100 lb. per yard. The shells are separated 6 in., and the space between is filled with plastic cement. Fig. 5 gives a general idea of the method of placing the boilers. Each setting is 18 ft. 6 in. wide, with the boilers 6 ft. 6 in. center to center. The stokers are each 6 ft. 2½ in. wide and extend under the boilers 9 ft. 9½ in. They are operated by the fan blower, Fig. 6. From the top tuyeres to the boiler shells the distance is 3 ft. 6 in., and the top of the bridge-wall is 4 ft. from the bottom of the shells. The combustion chamber back of the bridge-wall is 11 ft. 9 in. wide and 12 ft. 9 in. long, with a height of 5 ft. 6 in.

Forced draft is obtained from an 8x10-in. engine-driven 9-ft. fan blower running at 320 r.p.m., which delivers air to a main duct 5 sq.ft. in area, running along the rear end of the boilers, and from which two branches, each 18 in. square, are taken to each stoker. These branches join to a wind box below the stoker. An air pressure of from ½ to ⅝ in. of water is maintained

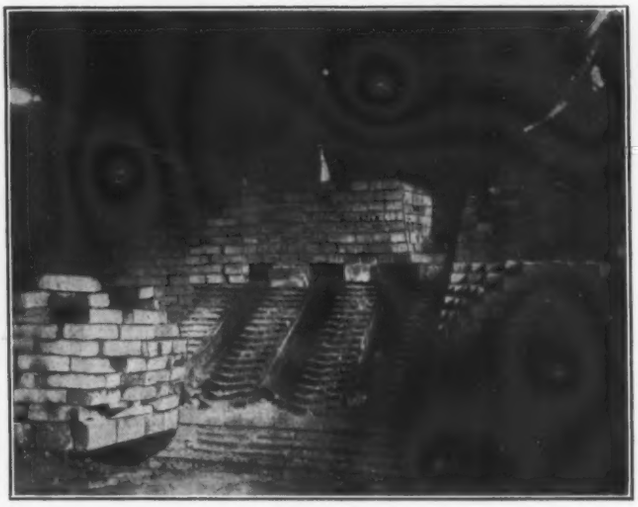


FIG. 4. FURNACE AND STOKER SERVING TWO RETURN-TUBULAR BOILERS

in the box under the stokers. Fig. 6 shows the general arrangement of the boiler, fan and air ducts and ash-disposal trench.

The bone fuel now used with the stokers is removed from the mine after being cut out from between the two seams of coal, and is hoisted to the surface, dumped into a single-roll crusher and then discharged to a double-roll crusher, which delivers it to a belt conveyor in

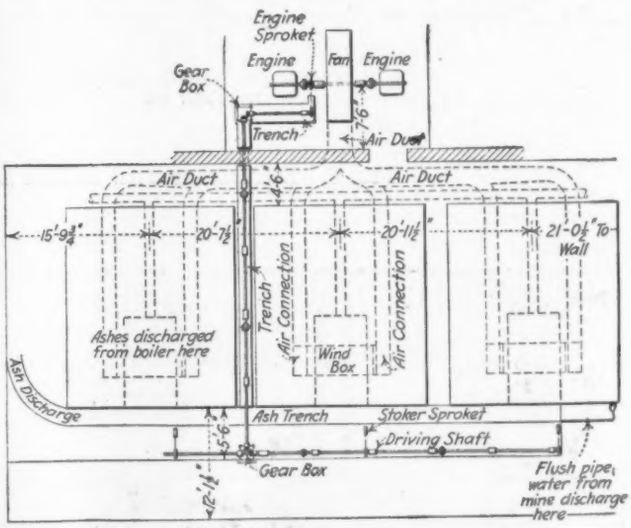


FIG. 5. PLAN OF BOILERS, ASH TRENCH AND AIR DUCTS

sizes not larger than 1½-in. It is then carried to an overhead bunker having a capacity of 250 tons, or about two days' supply.

It is interesting to note that under former operating conditions eight boilers were required to carry the load, and about 100 tons of marketable coal was burned each 24 hours; the boiler-room force consisted of 10 men, five to each 12-hour shift, and it was difficult to keep

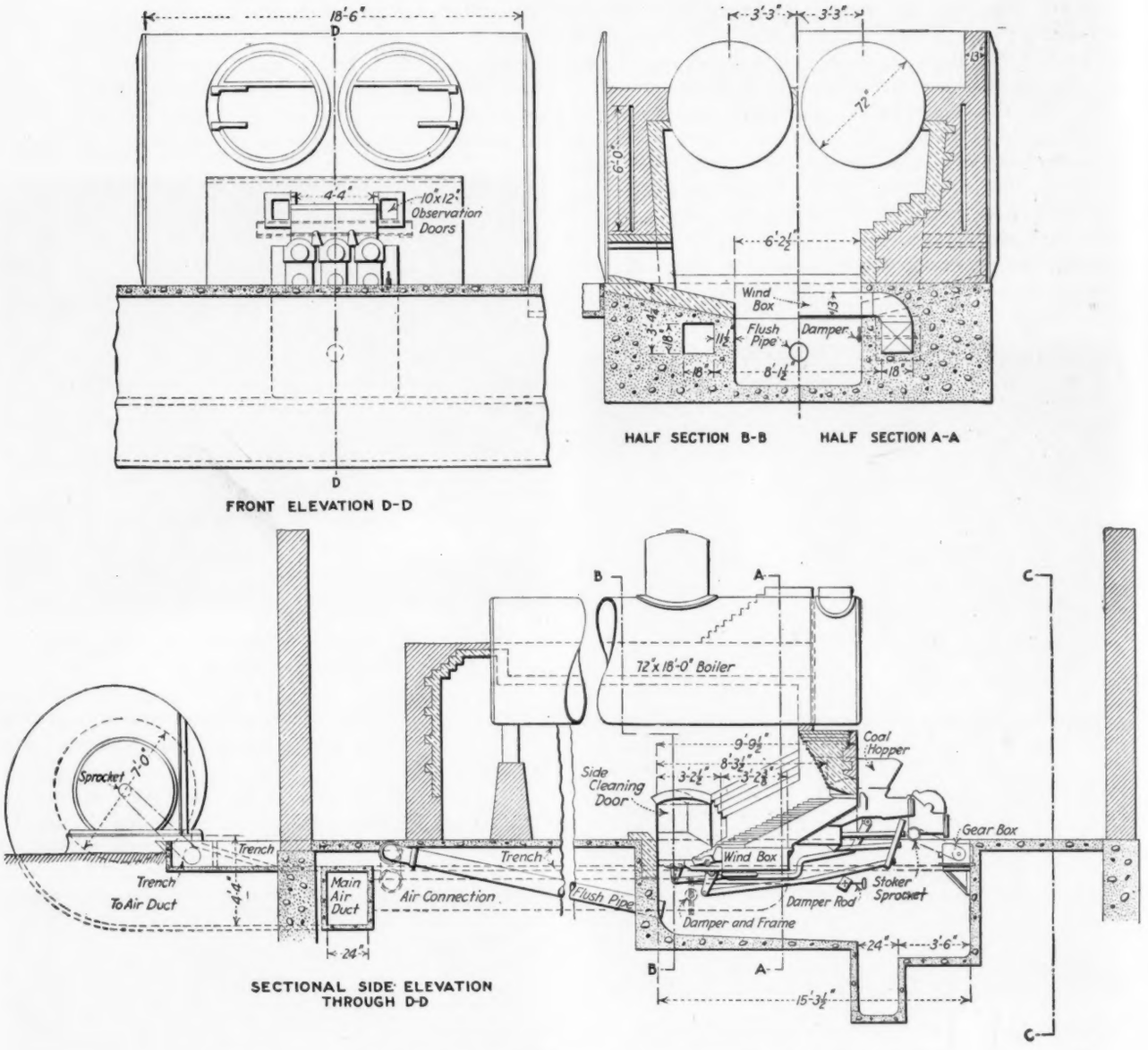


FIG. 6. DETAILS OF THE BOILER SETTING, AIR DUCTS AND ASH TRENCH

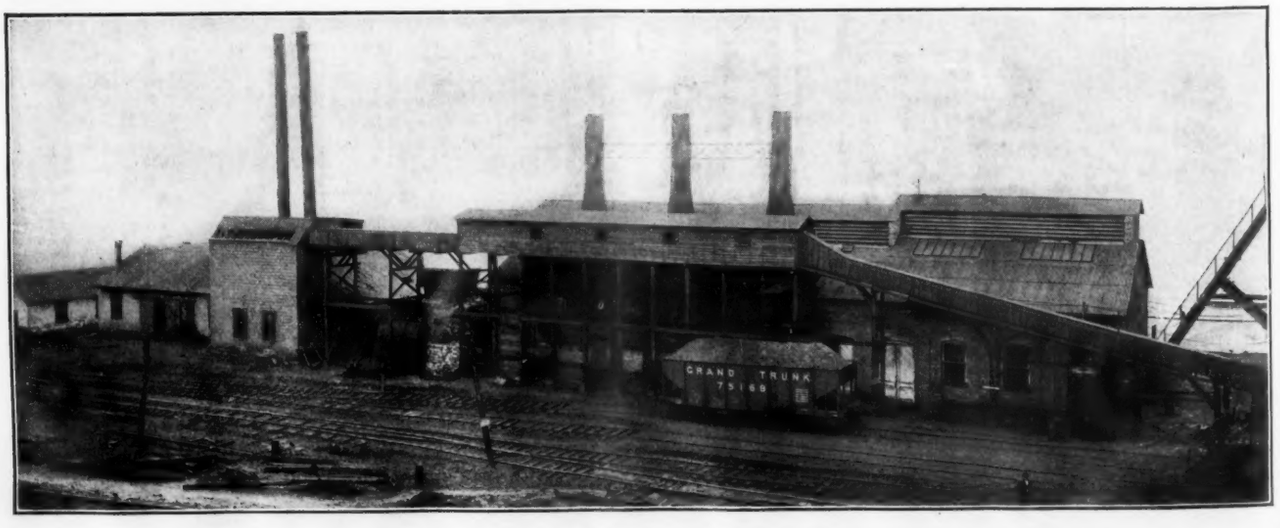


FIG. 7. GENERAL VIEW OF THE POWER PLANT OF THE BESSEMER COAL & COKE CO.

them owing to the hard firing conditions. The six boilers with their stokers now carry a heavier load than before the change, owing to the increased output of the mine and the substituting of an electric haulage system in place of mules. The boilers total 900-hp. normal rating, but have frequently delivered from 1600 to 1800 hp. with but three men on a shift, or six men for the 24 hours.

One hundred dollars' worth of marketable fuel is saved a day, and refuse that formerly cost about $6 a car to

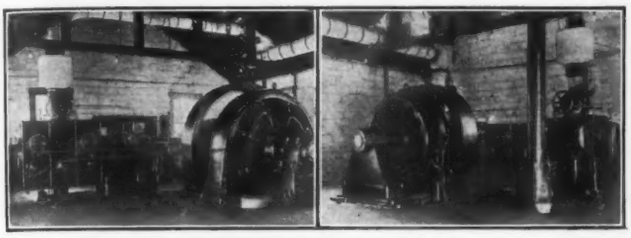


FIG. 8. THE TWO GENERATING UNITS

remove for filling-in purposes is for the most part burned in the boiler furnaces, and the removal cost of between $300 and $400 per month is saved.

An interesting method of disposing of the ashes has been worked out. They are flushed from the ashpit by a 10-in. stream of drainage water pumped from the mine. In front of the boiler a trench has been constructed, as shown in Figs. 5 and 6, 24 in. wide at the bottom, but with a shelf 3 ft. 6 in. wide at the top, making a total width of 5 ft. 6 in. The extreme depth of the trench is 3 ft. 6 in. The purpose of the shelf is to give an additional water head for flushing out the ashes.

The ashes are shoveled into the trench, which is below the level of the ashpit. A gate is provided at each boiler and when ashes are to be removed the last gate is closed until a head of water is obtained, when it is opened and the velocity of the escaping water carries the ashes with it. The plant is located at a considerable elevation and the trench discharges at the edge of the hill where there is sufficient ground to take care of the ashes for years to come.

The boilers are fed under normal conditions through a top connection, but in case of an emergency they may be fed through the blowoff. Each boiler connection to the header is provided with a nonreturn valve and the 12-in. header is likewise protected. A steam pressure of 100 lb. is maintained by the automatic speed control on the blower engine.

A general view of the plant from the railroad side is shown in Fig. 7. The three 45-ft. stacks serve the six boilers, and the two taller stacks the other two. At the extreme left is the engine room, which contains two units: One a 500-hp., four-valve engine directly connected to a 300-kw., 550-volt, direct-current generator at 150 r.p.m.; the other a 300-hp. engine directly connected to a 200-kw., 550-volt, direct-current generator at 180 r.p.m. The hoisting engine is in another engine room; it has a 26x36-in. cylinder and operates a hoist 260 ft. deep at a rate of 170 cars per hour, with an average of two tons per car.

A 10x10-in. engine directly connected to a 40-kw., 220-volt, direct-current generator is used for town lighting, and as it is in the hoist-engine room, requires no special attention.

The plant has attracted considerable attention because of several novel features, but chiefly because of the burning of a fuel that it had previously been impossible to use in a boiler furnace.

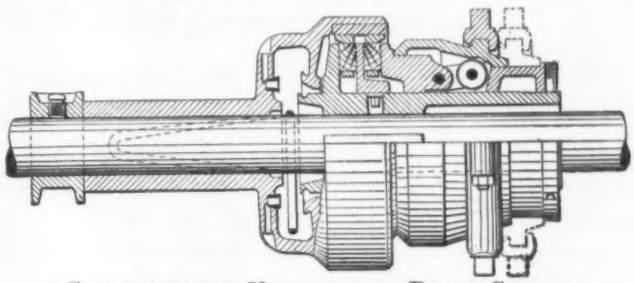
Dodge Safety Self-Oiling Clutch

An improved solid multiple-disk friction clutch that retains all the good points of the present clutch, with the addition of the important features of safety, efficiency and durability, has been developed by the Dodge Manufacturing Co., Mishawaka, Ind.

All moving parts of the mechanism of this new clutch, illustrated herewith, are concealed, making a smooth contour, so that there are no projecting moving parts. The design of the multiple friction disks, combined with the new roller toggle-operating mechanism, makes it a powerful clutch for its size.

The rolls on the toggle levers travel on conical surfaces arranged to give high pressure on the friction disks with a minimum amount of mechanism friction. The use of rollers in place of sliding parts makes the device easy to operate. The action of centrifugal force tends to keep the clutch disengaged when thrown out.

The apparatus is self-lubricating. An oil ring, revolving in a large chamber, or oil reservoir, carries a continuous supply of lubricant, which is circulated



SEMISECTIONAL VIEW OF THE DODGE SAFETY SELF-OILING CLUTCH

through suitable grooves to all parts of the sleeve carrying the pulley. This chamber is sealed to prevent oil working out into the mechanism. The shifter ring for engaging the clutch is made with a channel section that retains oil and assures lubrication at this point.

The clutch can be easily adjusted with a single nut adjustment that is simple and positive. Backing off this nut permits of the removal of the operating cone; this exposes the toggle mechanism and allows the removal of the inside mechanism for repairs. The best materials are used throughout.

The device may be easily applied to stationary or portable tools or countershafts, as well as pulleys, gears, sprockets, etc., and is especially suitable for high speeds.

Pasadena Electric Rates—Electric consumers in Pasadena, Calif., had to pay 15c. maximum per kw.-hr. up to 1908, when the city erected its own plant. The private company began its fight against the city by a reduction to 12½c. The city began operations with an 8c. rate; the private company met it. In 1910 the city made its lighting price 5c. maximum with a wholesale rate of 3c. and a power schedule of from 4c. to less than 1c. It is estimated that the saving to the city has been $100,000 per year since the plant was established. In 1913 the private company tried to put the Pasadena plant out of business by making its maximum rate 4c. in Pasadena, while it charged surrounding towns with no public plants at 6½c. to 10c. The State Legislature prohibited the company from making the other towns bear the losses of the company in Pasadena.—New York "American."

Getting Capacity in the Refrigerating Plant

By A. G. Solomon

SYNOPSIS—Is the plant that you have spent so much time on this spring giving its rated capacity? Is the condenser handling the gas as it should? Is the gas going to the compressor at the proper density and pressure, or is it superheated far more than is unavoidable? Can you add more load? These questions are well considered in this article.

During the next six months there are several questions which the engineer will ask himself: Is the full tonnage being got out of the plant? Are the ammonia compressors handling the amount of gas they should? Is the gas going to the compressors at the proper density and temperature? Are the direct-expansion coils handled properly? Are the brine and ice tanks handled right? Are the ammonia condensers doing their share of the work? Is the ice machine big enough to do the work demanded? Can a little more load be added?

The main question is to get the full capacity when it is needed. One part of the system may be holding all the other parts back.

Usually, the compressor is the first part considered and blamed when the temperature of the coolers and freezers begins to increase. In most cases putting the blame on the compressor is not justified. There is not much that can go wrong with the compressor. Leaky valves and pistons may happen, but are not likely except from long service. If the valves are ground in once a year and the cylinders and pistons examined and put in good condition at the same time, they will remain tight during a season's run.

Scale and dirt from the pipework may cut cylinders and valves, but there is little excuse for this. There are scale traps (or should be) on the suction lines to the compressors, and if they are cleaned at regular intervals the scale will be caught. All new pipe intended for ammonia systems should first be hammered and scraped to remove the scale. With reasonable care the compressor should give little trouble.

Condition of the Ammonia

So this really puts the success or failure of the plant on the manner in which the ammonia is handled. First, we will have to be sure that it is really anhydrous ammonia that we have in the system. There are two things that may be circulating in the system and taking up room and not giving good results. They are noncondensible gases and moisture. The so-called air is the most common and manifests itself as follows: Increased condenser pressure and consequently increased back pressure; frost melting from the machine and from the suction line; whistling sounds at the expansion valves; high discharge temperature and warm liquid lines and receiver. Sometimes, an insufficient charge of ammonia is taken as a sign of air in the system. The symptoms are somewhat the same. There should be a glass gage on the liquid receiver, and this should show at least half full when the machine is running on its proper load. If the liquid gets low in the receiver, the gas is allowed to enter the liquid line and then passes on to the evaporating coils, the compressor and condenser.

It goes through the evaporating coils, and instead of taking up heat by being vaporized it simply becomes superheated. The heat taken up by this gas is as nothing in comparison to that absorbed by the liquid, but the power required to pump it is about the same. So, before purging the system of air, put in enough ammonia to fill the receiver at least half full. Then, if there are indications of air, purge the condensers. Do not expect to get all the air out at one purging, but keep at it once a day till it is gone.

Moisture is sometimes allowed to remain in the system from careless handling during the steaming out of the evaporating coils. This does not often happen and seldom is the cause of serious trouble. Moisture in the system will in time show up in the oil traps and in the discharge-gas receiver. It will look like dirty water and is often called dead ammonia. No matter how full of ammonia this water is, it has no place in the system if it lies in the bottom of the gas receiver or oil trap. If there is an ammonia regenerator or purifier in the plant, the good ammonia can be boiled out and the moisture drawn off. But if there is no purifier, throw the dead stuff into the sewer. Noncondensible gases and moisture should not be troublesome in the plant, for they are easily got rid of.

Handling the Expansion Valves

Every engineer who operates a refrigerating plant is sure that he knows just how to handle the expansion valves to get the best results. It is a simple matter to open an expansion valve when a coil in a warm room is to be frosted.

We will assume that the cooler temperature has increased to 55 deg. The direct-expansion coils are either in a pipe deck above or else in the cooler itself. These coils are all free of frost. The proper way to begin to refrigerate this room will be to put on one coil and let it take up the steam and moisture from the atmosphere. This coil will frost quickly and will clear the room of steam. When frosted all the way to the return it should be shut off and another one put on. Do not open the expansion valves on all the coils at the beginning. This method of handling is to be recommended for two reasons. First, it will keep the coils more free from heavy frost and will give at least one clean coil to finish with. The coils that are used at first will be clean again, as the frost on them will be light, although thick, and will melt quickly.

The other reason is not so often considered, as its effect is not so plainly seen. We know that the ammonia that is in the coils when the room is hot is in a superheated state. The temperature of this gas will be the same as the temperature of the room. This gas will have to go through the ammonia compressor on its way to the condenser. The capacity of the compressor is rated by the

weight of ammonia which it handles. The gas is light and occupies more space than a saturated vapor of the same weight. If this superheated gas is all sent to the compressor at once it will (for a time varying from fifteen minutes to one hour) greatly reduce the capacities of the compressor and the condenser.

To get an idea of how much difference there is in the space taken up by saturated vapor and superheated gas we have only to look at the ammonia tables. At 15.67 in. pressure one pound of saturated vapor will occupy about 9 cu.ft., while a pound of gas at a temperature of 55 deg. under the same pressure will occupy about 11 cu.ft. This superheated gas coming from the coils in the warm rooms will meet the saturated vapor from the coils in the cold rooms and cause superheating of the ammonia passing through the suction line on its way to the compressor.

If a wet or humid gas machine is used, a greater amount of liquid injection will have to be admitted during this time to keep the cylinder cool. If the compressor depends on a water jacket for the removal of the heat of compression, the gas will become more superheated on its admission to the cylinder. The temperature of this gas often reaches 150 deg. at the end of the suction stroke. No matter which way it is looked at, there is a distinct loss in refrigerating capacity when the warm cooler is first put on. By frosting one coil at a time and, by so doing, sending the hot gas to the machine in small quantities, the loss will not be so great. Another good plan to follow is to shut the expansion valves on all the coils in the rooms having a temperature below 32 deg., while getting the coils in the hot room frosted. These coils will then pump down and give up whatever ammonia is in them. This will give a greater amount of liquid to be circulated through the hot coils, and when they are first put on they will be able to evaporate more than when they become frosted. We know that the expansion valves can be opened much wider on a hot coil than on a cold one, as the greater temperature and amount of heat will evaporate much more ammonia. But do not forget that as the temperature of the room is lowered, the amount of ammonia fed to the coils must be decreased. If the expansion valves are left as first set, the ammonia will soon go to the compressor in a liquid state. This liquid will, by reexpansion, cut down on the capacity of the compressor. The condition of the ammonia reaching the compressor should be regulated by means of observation of a thermometer in the suction line. The closer this temperature is to the temperature of the saturated vapor at the pressure shown on the back-pressure gage, the greater will be the weight of ammonia handled by the compressor at a given speed.

Pipe Insulation

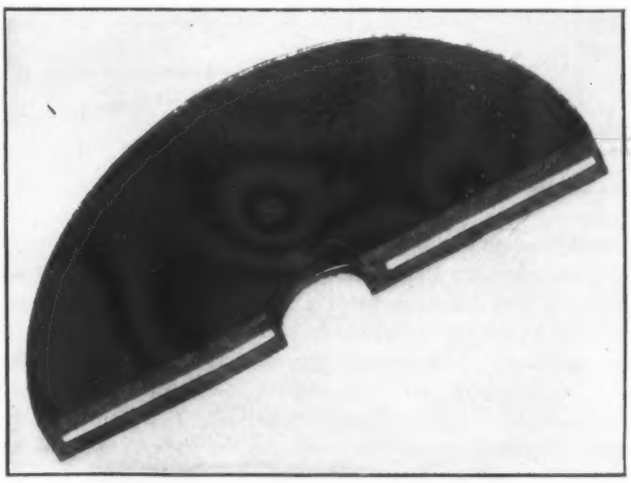
Superheating the ammonia by allowing heat to be absorbed through uncovered suction lines is a direct loss. A good rule to follow in a refrigerating plant is: Any pipe or apparatus which contains ammonia and is not used in the absorption of heat or the giving up of heat should be well insulated. This means to cover everything except the evaporating coils and the condensers. But the discharge line from the compressor to the condenser need not be covered, as the surrounding air will help to take away the heat caused by compression. The ammonia liquid line need not be covered in such places where the temperature of the rooms through which it passes is lower than the ammonia in the pipe. Do not allow an uncovered liquid line or a liquid receiver in a place where the temperature is higher than the condensing water used on the ammonia condenser.

The ammonia goes to the condenser to give up the heat it collected while evaporation was taking place. Here, we see the loss in condenser capacity caused by superheat. The gas must first be reduced in temperature to that of the saturated vapor at the condenser pressure before liquefaction takes place. So some of the condensing surface is used in taking away this superheat instead of liquefying and cooling the ammonia. After the ammonia is liquefied it should be cooled to the temperature of the coldest water available. Most plants use a cooling tower and reservoir and have a well or city-water line for making up what water is used or lost by wind and evaporation. This makeup water is, as a rule, much colder than the reservoir water and should be used for cooling the liquid before it is allowed to mix with the reservoir water.

The even distribution of water on the condenser is also necessary. Do not have some coils flooded while others are nearly dry. Have every foot of pipe doing its share of the work. Small leaks must be attended to just as soon as they are found, as they are generally the sources of loss of the ammonia. The big leaks are fixed at once, and the small ones should receive the same strict attention.

"Rub-Steel" Pump Valve

This pump-valve disk is a combination of rubber and steel. It consists of a steel plate placed in the center of the valve with a rubber composition on each side and edge; the rubber is attached to the metal by a chemical process. The plate embedded in the rubber is shown in the illustration. Its object is to give such strength to the valve that the pressures against which it works cannot



Reinforced Rubber Pump Valve

warp, twist or in any way get it out of shape. The rubber surfaces afford the proper seating qualities.

On account of the rigid reinforcement, the valve is kept in its true shape, high pressure is prevented from forcing the valve through the web of the valve seat and dishing of the valve is avoided.

The "Rub-Steel" valve disk is manufactured by the Voorhees Rubber Manufacturing Co., 18-50 Bostwick Ave., Jersey City, N. J.

Operation and Design of Auto-Transformers

By Norman G. Meade

SYNOPSIS—The uses of auto-transformers and some of the corresponding connections; also the calculations and directions for constructing one of 10-kw. capacity.

The most common use for auto-transformers is the starting of induction motors, to supply a gradually increasing voltage as the motor accelerates. Other applications are balancing coils for three-wire distribution systems and three-wire direct-current generators, single-phase railway systems, and for general service where the ratio of transformation is not large.

There is only one winding per phase, serving as both primary and secondary, as is shown by the circuits of a single-phase auto-transformer in Fig. 1. Here the same number of turns is required as in the primary of a two-coil transformer of equivalent rating and where the ratio of transformation is approximately 2 to 1; also the same weight of copper as in the primary winding of such a transformer. The voltage per turn is uniform throughout the winding, and to secure a low-tension voltage of 55 when the high-tension voltage is 110, it is necessary only to make a tap midway between the ends of the coil, as shown.

To supply 1100 watts on the low-tension side requires a current of 20 amp., but as this is opposed in time phase relation to the high-tension current in this section, there will be only 10 amp. flowing in the coil. Owing to excessive magnetic leakage when the windings are continuous, as in Fig. 1, it is customary to make up the winding of several interspaced coils as shown in Fig. 2.

Figs. 3, 4 and 5 represent, respectively, two V-connected auto-transformers arranged for starting a three-phase induction motor, three single-phase auto-transformers, Y-connected, for starting a similar machine; and two auto-transformers, one connected to each phase of a two-phase, four-wire circuit for starting a two-phase motor. Ordinarily, there are several taps in each auto-transformer connected to a controller to provide a gradually increasing voltage for starting.

Delta connections of a three-phase auto-transformer are shown in Fig. 6 and the Y-connections of a similar auto-transformer in Fig. 7. Both of these arrangements may be used for stepping up or stepping down the voltage.

Auto-transformers as applied to three-wire systems of distribution are shown diagrammatically in Figs. 8 and 9. In the former the auto-transformer is connected across a 220-volt line with the neutral tapped in at the center, giving 110 volts between each outside wire and the neutral and 220 volts between the outside wires. In Fig. 9 the auto-transformer is also designed for 220 volts, but is connected to a 110-volt circuit from one end tap and the center tap, giving the same voltages as in Fig. 8.

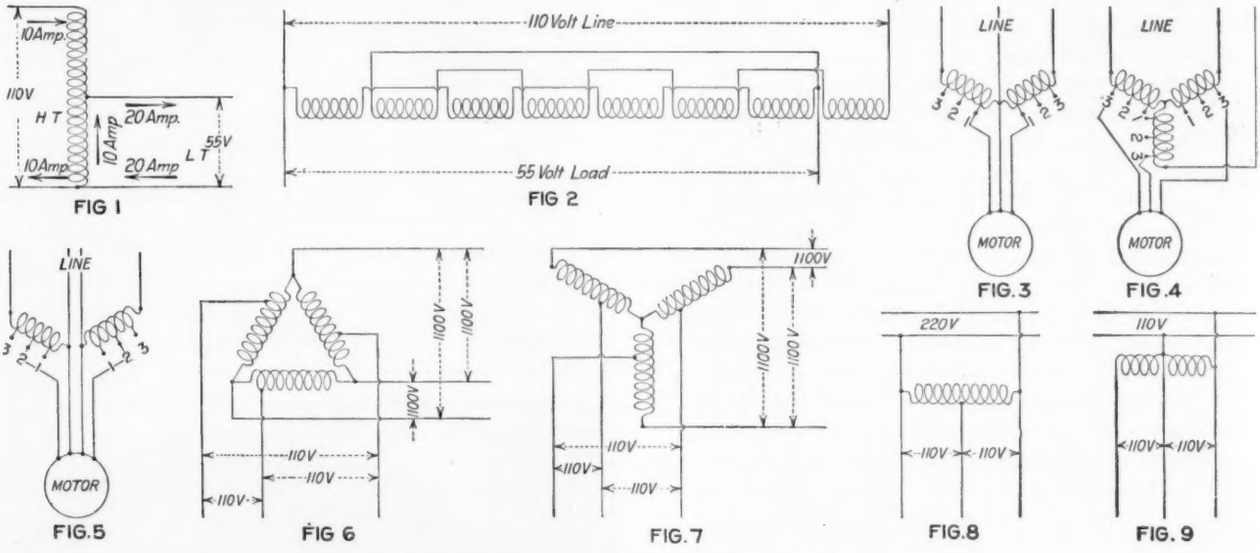


FIG 1 FIG 2 FIG.3 FIG.4 FIG.5 FIG 6 FIG.7 FIG.8 FIG. 9

Connections for Auto-Transformers

Design of Auto-Transformers

Assume that it is desired to design an auto-transformer of 10-kw. capacity for a 25-cycle, 440-volt circuit with a 2 to 1 ratio of transformation, the low-tension voltage to be 220. Let it be of the core-type construction with two legs and let the winding be divided into eight coils, four per leg. Assume the efficiency to be 95 per cent.

$$Efficiency = \frac{watts\ output}{watts\ input}$$

Then for an output of 10,000 watts the input will be $10{,}000 \div 0.95 = 10{,}526$ watts.

This limits the total full load loss to 526 watts, which should be about equally divided between the core losses and the copper loss, with perhaps a little greater copper loss. Therefore, let the copper loss be 300 watts and the core loss 226 watts. Assume a magnetic density of 30,000

lines per square inch of cross-sectional area of the core, which is a fair value for 25-cycle circuits. Then from curves showing hysteresis loss it will be found that for a density of 30,000 lines at 25 cycles, the loss is 0.1 watt per cubic inch of core for a good quality of soft iron in sheets.

The eddy-current loss will be small in a properly constructed core; hence it may be taken as 26 watts and the hysteresis loss 200 watts. Then the volume of the iron in the core will be $200 \div 0.1 = 2000$ cu.in. The plates should be from 16 to 20 mils in thickness for 25-cycle circuits, and the oxide on the plates with a sheet of paper placed about every half-inch should be sufficient insulation. The volume of the iron core has now been determined, and it remains to proportion the core itself. Fig. 10 shows the type of core selected, and in proportioning it due regard must be given to the winding.

The core will be made square in cross-section, with the corners chamfered slightly. If the cross-section is made very small, the cores will be long and thin, the magnetic flux N will be small, and the coils will have to be provided with a large number of turns to generate the required electromotive force. Long cores also give rise to a long magnetic circuit, thus increasing the magnetizing current. On the other hand, if the cores are made very short the wire will have to be piled up deep in order to get it into the winding space, and the yoke across the ends will have to be made longer. Deep windings also mean a greater length of wire for a given number of turns. The best proportions are largely a matter of experience. For preliminary dimensions let the proportions shown in Fig. 10 be used, all of the dimensions being expressed in terms of the thickness of the core. Make the height $7a$; the volume of the core will then be

$$V = (2 \times 3.5a + 2 \times 5a)a^2$$

a^2 being the area of cross-section and $5a$ the distance between the yokes. This gives

$$V = 17a^3 = 2000 \text{ cu.in.}$$

whence

$$a = \sqrt[3]{\frac{2000}{17}} = 4.89 \text{ sq.in.}$$

This would represent the thickness of the core if it were solid iron. Part of the cross-section, however, is taken up by insulation between the plates, and the corners are cut off slightly, so it will be well to make the core 5 in. square. The other dimensions shown in Fig. 11 follow from this.

The impressed electromotive force is equal and opposite to the resultant of the counter electromotive force generated by the winding and that necessary to overcome the resistance of the winding. The drop in the winding is small compared with the impressed electromotive force and for present purposes may be neglected, hence the counter electromotive force generated in the winding may be taken as equal numerically to the impressed electromotive force. The number of turns required to produce this will depend upon the magnetic flux N which threads through the windings. The maximum magnetic flux through the winding will be $N = B_{max} \times a$, where B_{max} is the maximum value which the magnetic density reaches during a cycle, and a is the cross-sectional area of the core. In this case B_{max} is 30,000 lines per square inch, and a is 25 sq.in. Therefore,

$$N = 30{,}000 \times 25 = 750{,}000.$$

Taking the electromotive force generated in the winding as the equal and opposite to the line voltage,

$$E = \frac{4.44 \times N \times T \times f}{10^8}$$

where

N = Maximum value of the magnetic flux through the core;
T = Number of turns on primary coil;
f = Frequency in cycles per second;
E = Impressed electromotive force.

Applying this to the present example,

$$440 = \frac{4.44 \times 750{,}000 \times T \times 25}{10^8}$$

$$T = \frac{440 \times 10^8}{4.44 \times 750{,}000 \times 25} = 528$$

To make ample allowance let the number of turns be 600, or 300 to each leg. The current equals $10{,}000 \div 440 = 22.3$ amp. Allowing 2000 circ.mils per ampere, the size of the wire will be 44,600 circ.mils, which corresponds nearest to No. 4 B. & S. gage. For this size of wire there are 4.5 turns to the inch. Allowing for insulation and space between coils, there will be approximately two layers on each leg. The approximate mean diameter of the coil is 7.5 in. and the mean length of one turn 23.5 in., say 25 in. The total length of the winding will then be $600 \times 25 \div 12 = 1250$ ft.

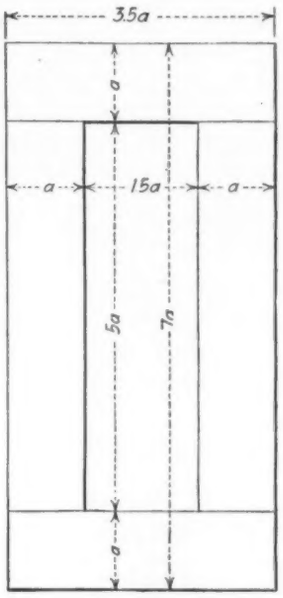


Fig. 10.

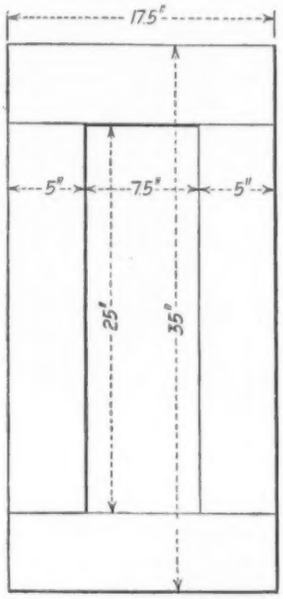


Fig. 11.

Core Dimensions

The resistance of No. 4 wire is approximately 0.25 ohm per thousand feet, which gives a resistance for the winding of approximately 0.32 ohm. The I^2R loss equals $22.3^2 \times 0.32 = 159$ watts. As the allowance for copper loss was 300 watts, this is well within the safe limits, and the efficiency will be greater than that assumed tentatively in the beginning.

Construction of Auto-Transformers

Having decided upon the core type of construction and determined the size of the core, the next step is to assemble the sheets. A wooden form should be provided, con-

forming to the internal dimensions of the core, and this should be laid on a level surface. Half of the iron sheets for the sides will be cut as long as the height of this form and half will be cut the overall height of the core. Similarly the ends will be made with half of the sheets as long as the width of the form and the other half as long as the overall width of the core.

Place two long strips, b and b' (Fig. 12), against the form and select two of the shorter end strips, a and a', and place them at the ends of the form. Next lay on two short strips b and b' and two long strips a and a'. This construction will give lapped joints. When the desired thickness of iron has been built up in this manner, the iron should be clamped, drilled and riveted, as indicated. The bolts can be removed and the top yoke withdrawn, leaving dovetailed connections for the top of the core. The core is then ready for the assembling of the coils.

The next step is to provide a form for the coils similar to that shown in Fig. 13. The distance between the collars should conform with the height of the coil, with the center slightly tapered to facilitate the removal of the finished coil. There should be about four slots on the circumference of each collar on the spool, in which pieces of cord are laid before winding is started. These cords are for binding the coil before removing it from the form.

Figs. 14 and 15 show, respectively, a partially completed and a completed coil. Flexible leads are soldered to the coil ends and insulated as shown. When the coil is wound, place a strip of flexible micanite around the inner surface and wrap with tape and cord at four places as shown, after which the temporary tie cord can be removed and the coil securely wrapped with webbing. It should then be heated to about 200 deg. F. and immersed in some good insulating compound and baked.

Provide some rounded hardwood blocks that have been thoroughly soaked in insulating compound and place them around the cores as shown in Fig. 16. Slip the coils in position with mica washers between them and between the top and bottom coils and the core. The coils should then be connected as indicated in Fig. 20, a, b, c and d being connected together as are e, f, g and h, and the leads joined as shown.

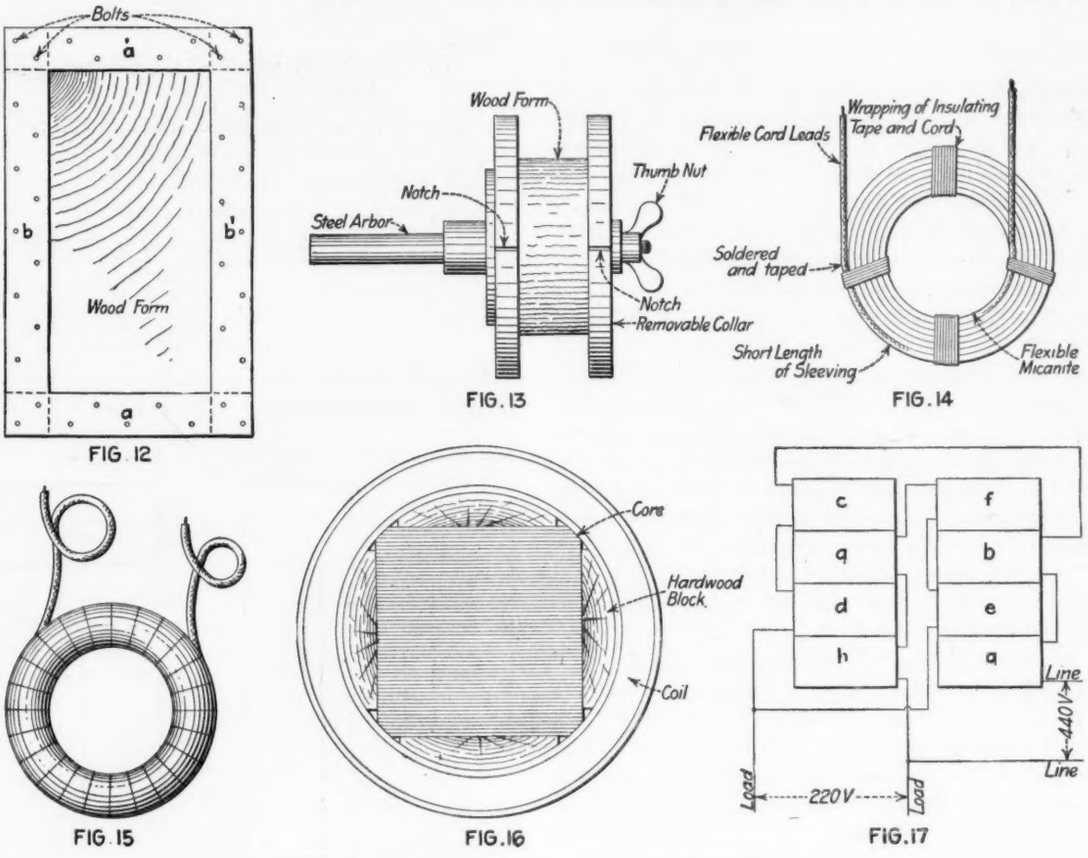


FIG. 12 FIG. 13 FIG. 14

FIG. 15 FIG. 16 FIG. 17

WINDING DETAILS AND COIL CONNECTIONS

...d Mail

...letter ...y Dep... Mulhall, ...ail for ...he let... ...d were ... the for Fed... ...ver

...in 1909 ... ...law class of that

...testified that she and her ...a had been living apart since ...ember, 1914. Mrs. Deboalt was represented in court by Attorneys Macomber and Pendleton.

Deboalt made no appearance and was unrepresented by counsel.

Trapped in Boiler Amid Hissing Steam

Andrew Monsen, a boiler cleaner, employed by the Equitable Light and Power Company, who lives at 61 California street, narrowly escaped being scalded to death in the basement of the Phelan Building this afternoon. While Monsen was working inside the boiler, the engineer, not knowing that he was inside, turned on the steam. Monsen was taken unconscious to the Central Emegency Hospita.

...in. ...as M. ...of th... Joao Mini... roz. Minis... Minis... eira Qu... Minist... Minist... Monteiro Minist... Costa. Minist... Magalha...

OAKL... his sister ...eloped w... residing ... today a... the cou...

SAFETY FIRST! A LOCKED VALVE WOULD HAVE PREVENTED THIS ACCIDENT

Improvements in V-Notch Meter

In the Mar. 31, 1914, issue, page 415, was illustrated the Hoppes V-notch meter in the original form. Since then several improvements have been made. There are many places in which the recorder had to be located where there was considerable vibration, and this not only

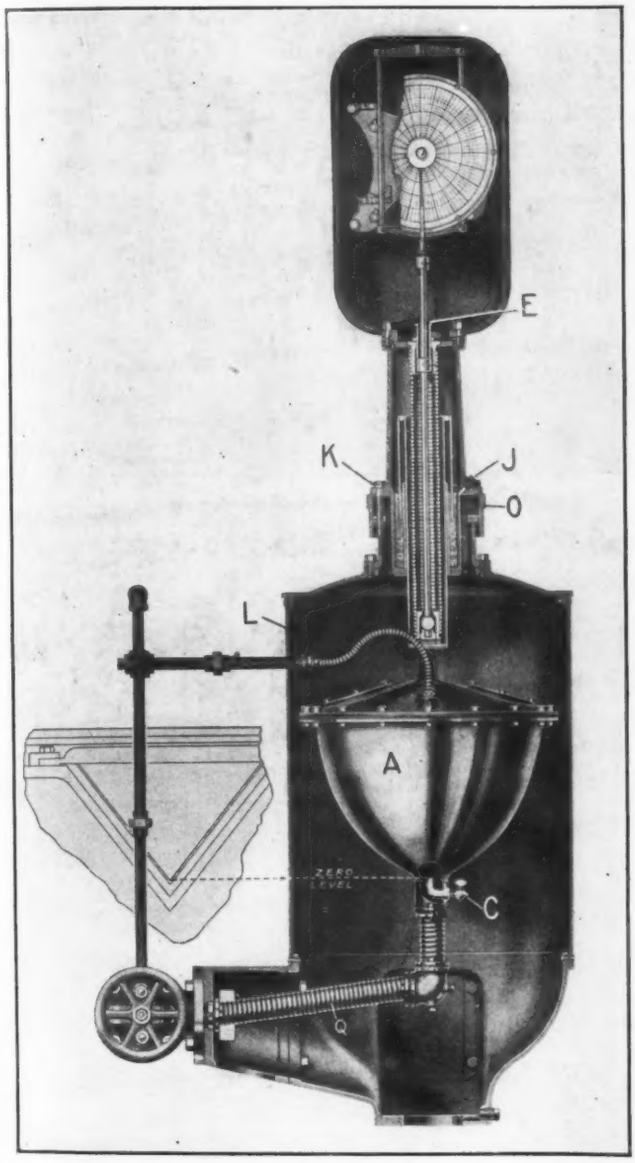


FIG. 1. IMPROVED WEIGHER RECORDER AND RECORDER HEAD

made a wide mark on the chart, but in some instances the integrator was so interrupted as to make it unreliable. To overcome these difficulties a much longer and heavier guide has been designed which has overcome the previous defects.

Figs. 1 and 2 show the changes made. In addition to improving the guide, the adjusting band *O*, Fig. 1, has been changed to the bottom of the column for adjusting the instrument to the zero level, which obviates the necessity for changing the brass sleeve *E*. All that is necessary now to adjust the zero level is to loosen the screws *K* and turn the band *O* up or down until the

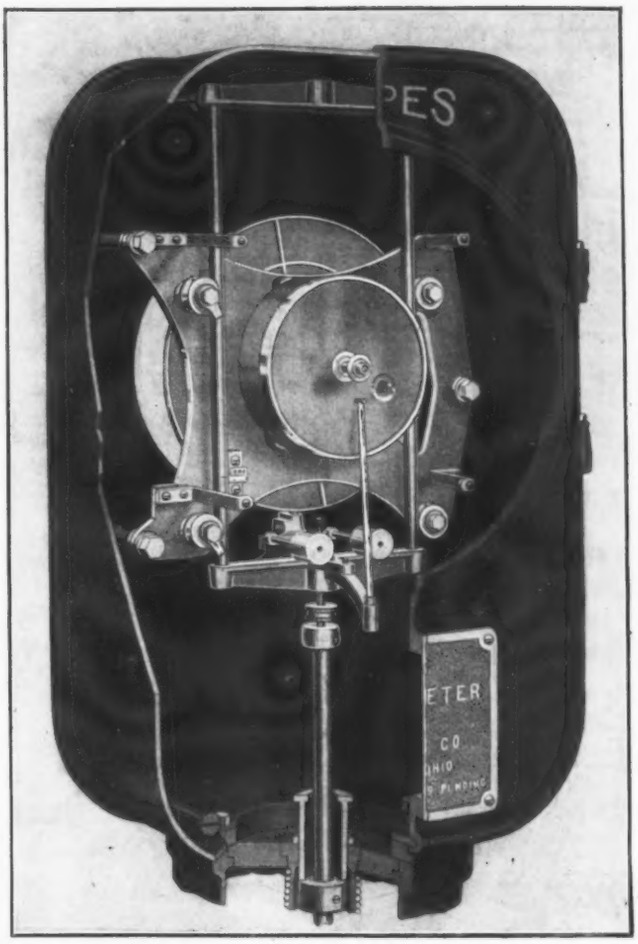


FIG. 2. IMPROVED RECORDER HEAD, SHOWING CHART SIDE OF THE INSTRUMENT

water drops slightly from the pet-cock *C*. All of the other adjustments have been made at the factory before shipment.

The improved recorder head, Fig. 2, is also made,

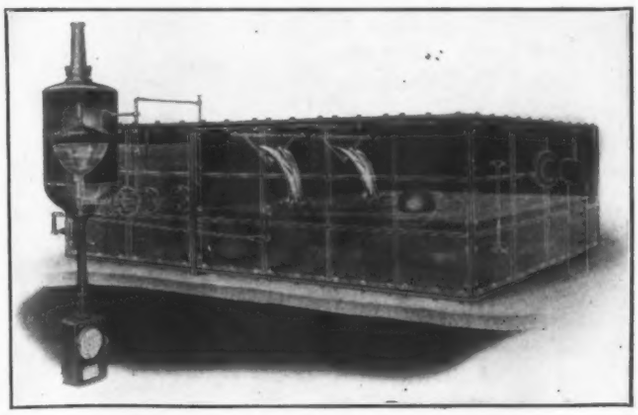


FIG. 3. RECORDER HEAD PLACED BELOW THE TANK AND CABINET

when desired, to be placed below the cabinet *L*, as shown in Fig. 3. This is a desirable feature where the meter tank has to be placed at a considerable elevation above the floor or on the floor above the room where it is desired to have the recorder head. This illustration also shows clearly the connection of the water behind the weir with the weighing vessel, *A*, Fig. 1. These improvements add to the adaptability of the meter.

Oxyacetylene Welding in Pipe Work

By W. Lee Roueche*

SYNOPSIS—Welded pipe is being more and more used each year, and the progress of its application is therefore of interest to watch. The relative cost of welded and flanged steam header favors the former. The article illustrates some interesting examples of pipe welding and gives valuable results from destruction tests on welded pipe.

It is only in the past decade that the design and construction of piping systems for power plants have received the careful thought and study of designing engineers which their importance warrants. Joints and massive fittings have been a potential source of trouble and expense, and a minimizing of their number is desired. The perfecting of the oxyacetylene torch has made this possible and also has enabled better engineering.

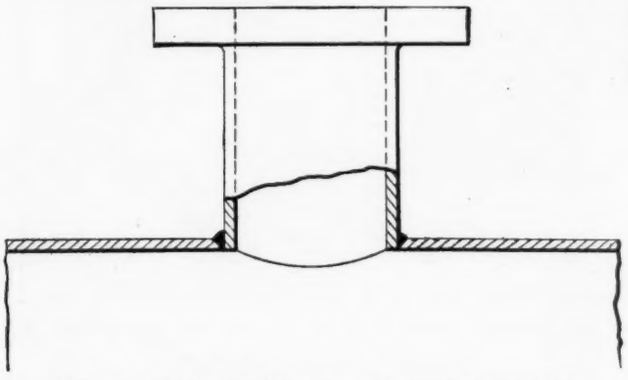


Fig. 1. Section Showing Construction of Welded Joint

The old-style header, built up with cumbersome flanged fittings, is fast becoming obsolete. It is now practical to build headers of the same relative strength as the pipe itself and in lengths limited only by shipping and erecting facilities. The relative cost is in favor of the welded header, more particularly in the larger sizes and where there are a number of outlets. A welded job is also much lighter, therefore easier to erect and support. It is built of the same material throughout and avoids the uncertainties due to defective castings and unequal expansion strains. The number of intermediate joints is reduced to a minimum, and in many instances they are cut out altogether. It has been found practical to close the ends of headers with convex heads, dished to the proper radius and welded on, thereby doing away with all joints except those at the nozzle connections.

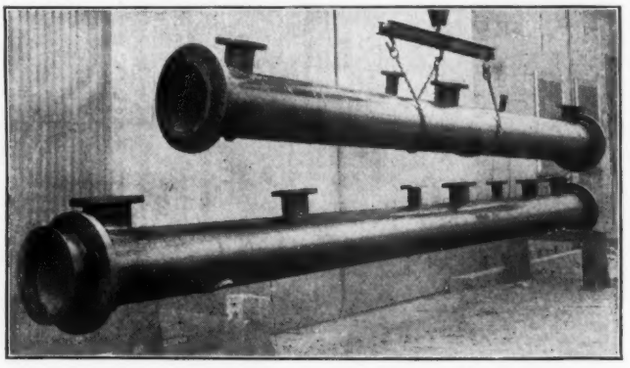


Fig. 2. Welded Header, 18 In. Diameter; Total Length 48 Ft. Note Outlets of Various Sizes

The usual method of construction is to take lap-welded merchant steel pipe of the proper diameter and thickness and where necessary weld together to get the desired length. The holes for the outlets are cut either in the usual manner or with the cutting torch. The nozzles are then welded on after being shaped to fit the curvature of the pipe. Different manufacturers have various methods of attaching the nozzles. The method used by the writer, which has proved to equal the strength of the pipe itself, is shown in Fig. 1. The pipe is beveled so as to form an angular groove of about 45 deg. with the nozzle. The fillet is then built up to the proper thickness. Nozzles of any size up to the diameter of the header itself have been successfully used. All welds are annealed after the header is completed, to relieve strains that may have been produced during the welding process. The

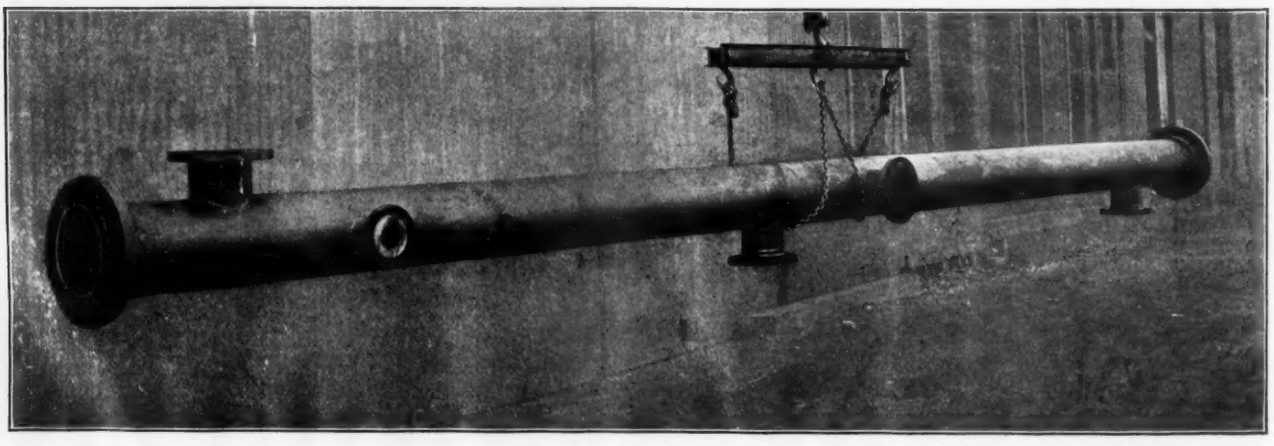


Fig. 3. Large Steam Header, 31 Ft. Long; Rolled Steel Flanges and Seamless Nozzles

*With Crane Co., at Birmingham, Ala.

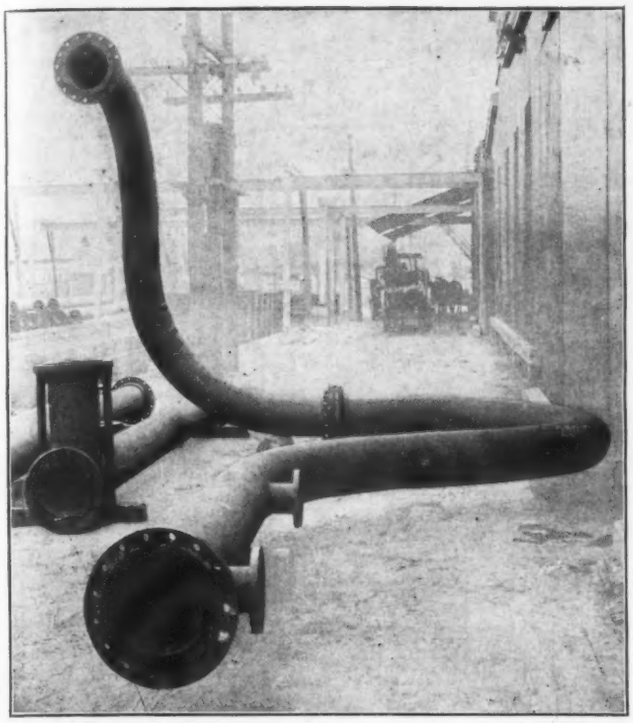


FIG. 4. EXAMPLE OF WELDING POSSIBILITIES

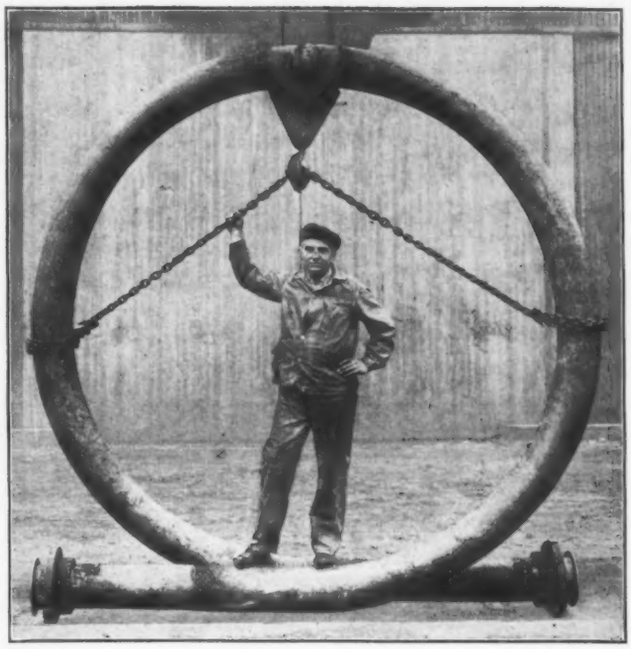


FIG. 5. AN 8-IN. EXPANSION LOOP HAVING 37 FT. OF PIPE. NOTE WELD AT THE TOP JUST ABOVE CRANE HOOK

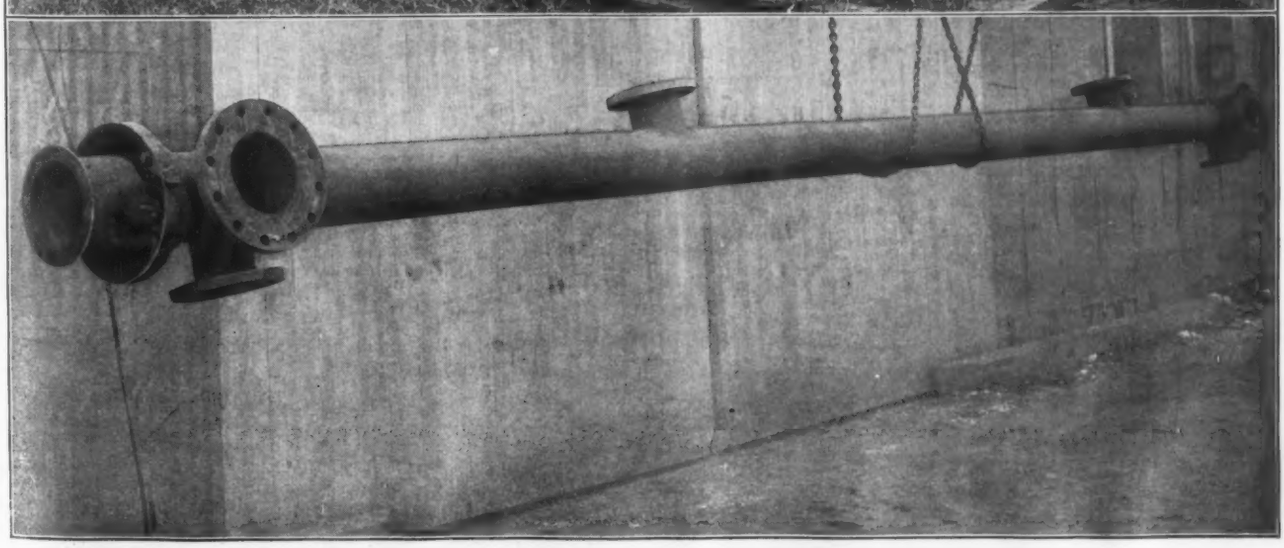


FIG. 6 (ABOVE). TEN LENGTHS OF 8-IN. PIPE EACH 40 FT. LONG
FIG. 7 (BELOW). AN 8-IN. HEADER, 30 FT. LONG. NOTE NOZZLES AT EACH END

usual test is a cold-water pressure 2½ times the working pressure.

Fig. 2 shows an 18-in. header 48 ft. over all, built in two sections, with six 7-in. boiler connections and five distributing outlets ranging from 2 in. to 10 in. This header was tested to 600 lb. hydraulic pressure and has been in successful operation for more than two years.

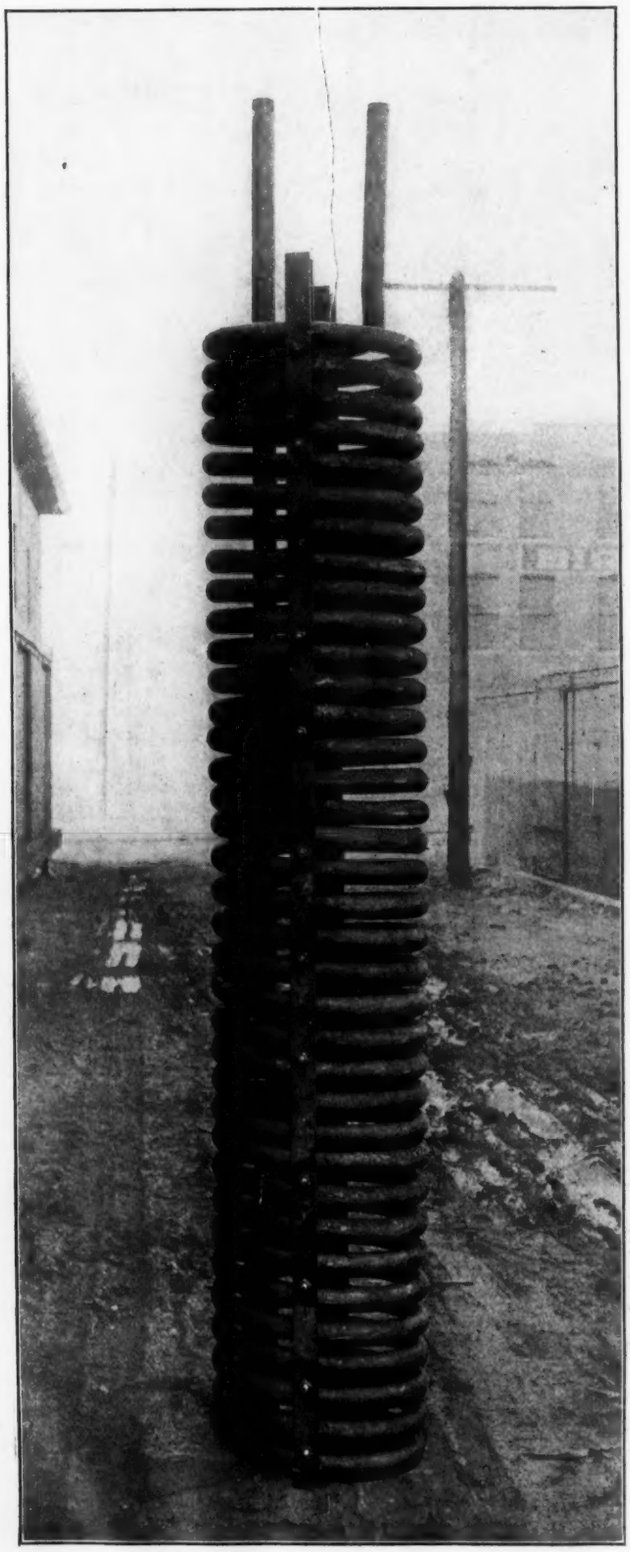


FIG. 8. PIPE COIL FOR AMMONIA PLANT; HAS 180 FT. OF PIPE

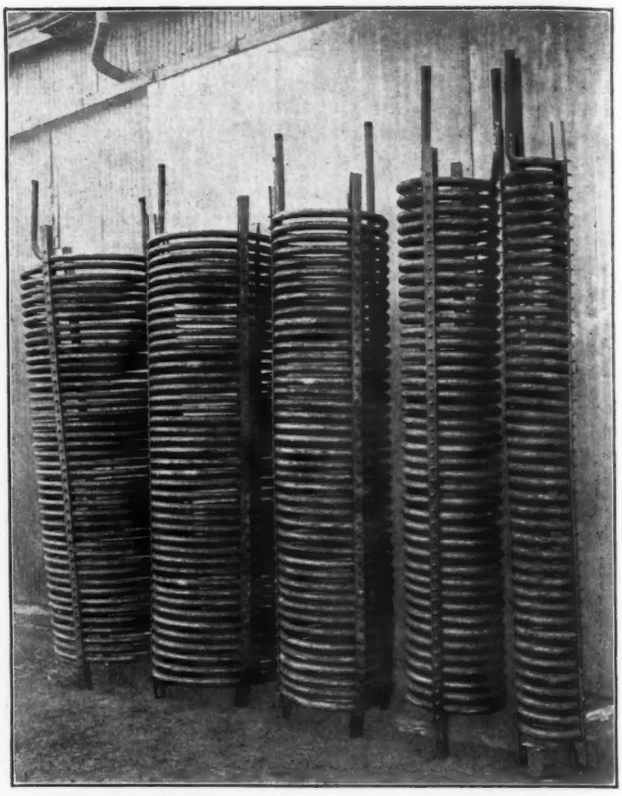


FIG. 9. FIVE COILS HAVING TOTAL OF 1400 FT. OF 1½-IN. PIPE

Fig. 3 shows a 14-in. header 31 ft. 2 in. over all, with four 8-in. and one 4-in. seamless steel nozzles.

Fig. 4 is a good example of work that would have been practically impossible without the welding torch. All the headers are of 14-in. o.d. pipe ⅜ in. thick. The gooseneck was originally made in four sections and then made into two by welding. The location of the welds can be clearly seen in the photograph. The whole was installed in the same relative position as shown. The 14-in. outlet on the middle header connected to the upper end of the gooseneck. These headers were built to meet a peculiar condition in a Southern plant and have been in service about two years.

Fig. 5 is a further example of the advantages of the oxyacetylene weld. This is a special 8-in. expansion U-bend made to suit special conditions. The weld can be plainly seen at the top, just over the crane hook. The finished bend contains 37 ft. of pipe.

In long runs of pipe it is possible to eliminate from 40 to 50 per cent. of the joints. Fig. 6 shows ten lengths of 8-in. pipe for a high-pressure steam line averaging over 40 ft. each.

Another good example of a welded header is shown in Fig. 7. This is an 8-in. header 30 ft. over all, with two 8-in., two 6-in. and two 5-in. seamless steel nozzles. The 8-in. and 5-in. nozzles are in the same plane set at 90 deg. to each other.

The possibilities of oxyacetylene welding in all classes of pipe have only just begun to be realized. It is being successfully used in ammonia work, where there is a wide field for it. Figs. 8 and 9 are good specimens of this class of work. The former is for a reboiler in an absorption plant. The coil is 19 in. outside diameter and contains 180 ft. of 1½-in. extra heavy pipe. Fig. 9

shows a set of the same kind of coils which nest together, the five coils containing about 1400 ft. of 1½-in. extra heavy pipe. These coils were tested to 800 lb. hydraulic pressure.

Destruction Tests of Welds

The writer has made several destruction tests in order to compare the strength of the weld with that of the pipe. These have proved conclusively the efficiency of the weld when properly made. In the first test, a piece of 12-in. full-weight pipe, 5 ft. long and equipped with lap-joints and rolled-steel high hub flanges, was used. A 4-in. seamless steel nozzle was welded on midway between the flanges, and the ends closed with extra heavy cast-iron blind flanges bolted on. At 2000 lb. hydraulic pressure one of the blind flanges gave way, while the weld showed no signs of stress. The second test was made with a piece of 6-in. full-weight pipe 5 ft. long. The pipe was cut in the middle and butt-welded with the torch. The ends were fitted with lap-joints and rolled-steel flanges and blanked with extra heavy cast-iron blind flanges. Three blind flanges were broken in succession at hydraulic pressures of from 2100 to 2300 lb. The bolts showed stress at 2300 lb. One end of the pipe was then cut off and a ⅜-in. thick convex head butt-welded on. A special flange was made for the other end and the bolts increased from twelve ⅞-in. to twelve 1-in. Hydraulic pressure was again applied. At 3300 lb. the flanged joint failed owing to the dishing of the rolled-steel flange. Neither weld on examination showed any indication of failure. The theoretical bursting pressure of 6-in. full-weight pipe, as given by the manufacturer, is 4200 lb., and this test was made without annealing the welds. It was found that the outside diameter of the pipe was increased almost ¼ in. The third test was made with a piece of 5-in. full-weight lap-weld merchant pipe about 6 ft. long, butt-welded in the middle as in the second test, and both ends closed with a ⅜-in. thick convex head butt-welded on. At 2700 lb. the seam of the pipe opened up. This was welded with the torch and hydraulic pressure again applied. At 3950 lb. the pipe burst, rupturing the metal longitudinally to one side of the seam where it had been rewelded with the torch.

Automatic Electric Control of Pumps

By George J. Kirchgasser

SYNOPSIS—An interesting description of the applications of automatic electric control devices for pumps in various kinds of service.

Probably the commonest type of motor-driven machine to which the automatic starter has been applied is the pump. From the small house and sump pump to the largest types used on water systems, automatic or remote control has proved of distinct advantage.

Sump pumps are used to keep basements clear of water. The basement floors of buildings of today are frequently below the level of the sewers and considerable water drains in after rains or thaws. A pit is usually provided so that this water is collected in one place. A small pump called a sump or bilge pump, usually driven by a vertical motor, is used to prevent overflowing into the basement. To automatically start and stop this pump so that there will be insurance against flooding the basement and against useless waste of electric power, is one of the common applications of the motor starter, or controller.

The illustrations, Figs. 1 and 2, show automatic controllers for direct-current and alternating-current motors.

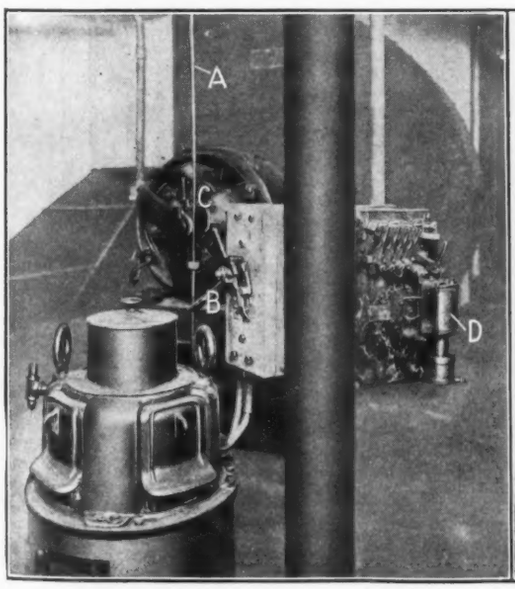


Fig. 1

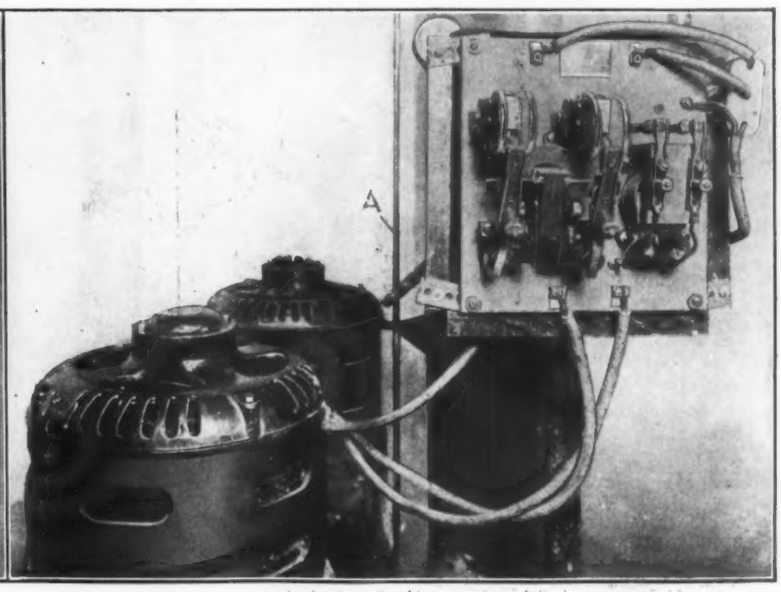


Fig. 2

Control Devices for Direct- and Alternating-Current Motor-Driven Sump Pumps

In the first the float switch is mounted so that its operation is easily explained. As the water in the pit rises, the rod *A*, mounted on a float, rises also. This rod has two stops, one of which is shown. As the float and rod rise, the lower stop engages the movable arm *B* of the float switch. When this moves through a certain distance the weighted tumbler arm *C* of the switch causes the latter to close, and this in turn causes the solenoid *D* of the starter to become energized. The motor is thus started and accelerated to normal running speed. The pump will be driven until the water level has been lowered to a predetermined point. When this is reached the upper stop on the rod will have tripped the float switch open, which causes the automatic starter to cut the motor from the line and thus bring it to a stop. The pump may be put in operation for long or short periods, it may be started and stopped many times a day or only a few times a year, but no attention is required, and current will be used only when necessary and for as short a period as required to lower the water to the desired level.

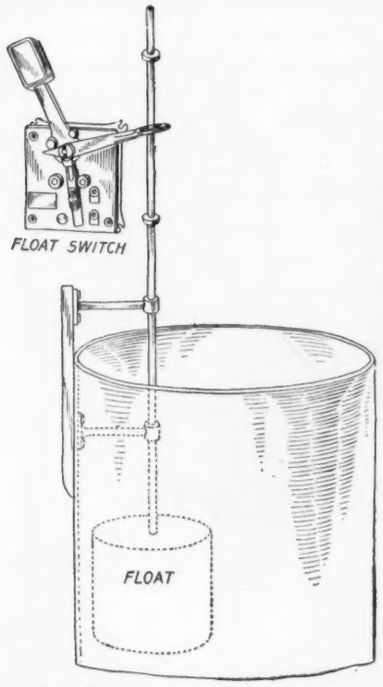


FIG. 3. THE FLOAT SWITCH

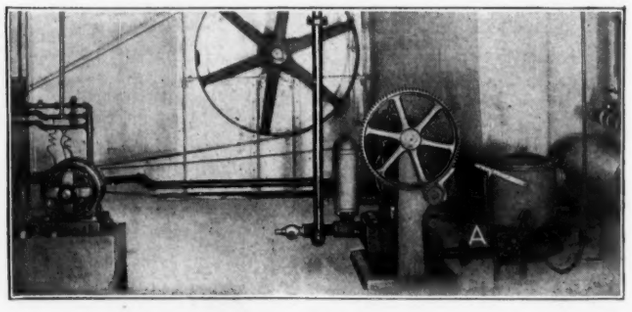


FIG. 4. THE FLOAT SWITCH OF THIS MOTOR-DRIVEN RETURN SWITCH IS ACTUATED BY THE WATER LEVEL IN THE PUMP GOVERNOR

For small sump-pump equipments operated by alternating-current motors the magnetic switch shown in Fig. 2 is used to throw the motor across the line or to cut it off, as the water level demands. In this installation the float switch, operated by the vertical rod *A*, is mounted on the post in back of the automatic starting-switch panel, one end of the lever alone being visible. Fig. 3 shows how the sump float is arranged.

Fig. 4 shows a simple but interesting application in a school building, of the same type of automatic switch and float switch. The latter is mounted near the floor (see *A*), while a magnetic switch is mounted on the wall and not shown in this view. A 7½-hp., three-phase, 60-cycle, 220-volt motor of the squirrel-cage induction type is used. Back of the float switch is shown the

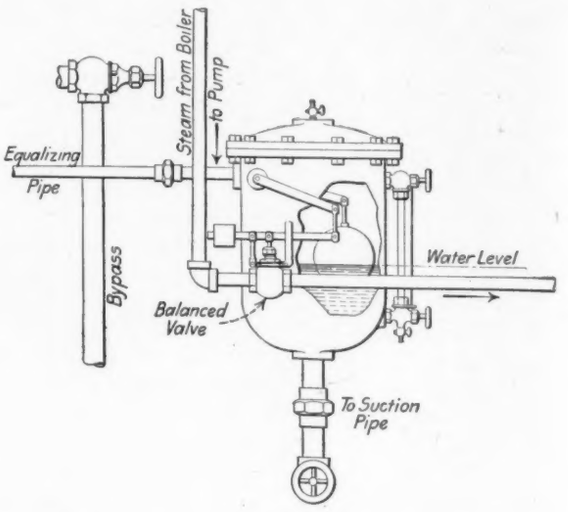


FIG. 5. SHOWING THE PUMP GOVERNOR

automatic pump regulator and condensation receiver used in connection with the steam pump to automatically return the condensation from the heating system or other apparatus to the boiler. Fig. 5 shows such a receiving apparatus for returning condensation to the boiler, in

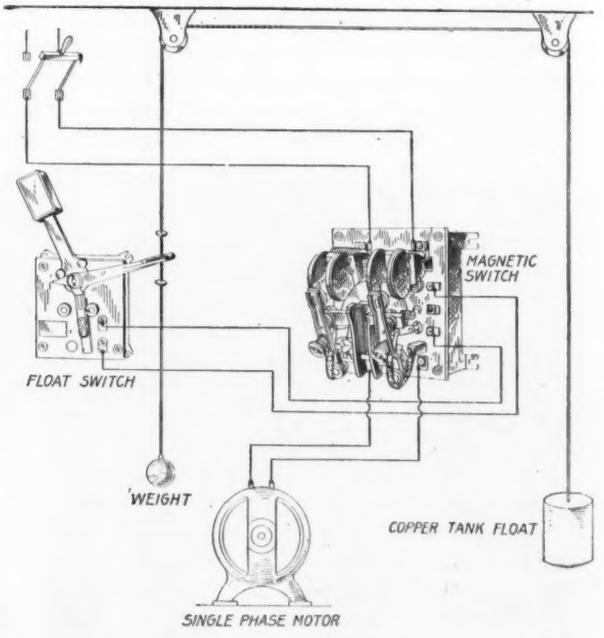


FIG. 6. AUTOMATIC STARTER FOR SINGLE-PHASE MOTOR

which an automatic pump regulator and condensation receiver are employed. As the water rises, the float is raised and at a certain level causes the tumbler arm of the float switch to close the magnetic switch and set the motor and pump in motion. The float switch does not carry the motor current, but simply the energizing current which causes a magnetic switch (as in Fig. 6) to close and connect the motor to the line. After the level

drops, the float switch is tripped open and the motor disconnected from the line.

In the keeping of any sort of open tank filled to a desired level the same methods of control may be used, except that the float and float-switch operations are opposite from those used in connection with the sump pump. In the ordinary tank system the motor is started and put in operation when the level is low and stopped when it reaches a desired high point. The same kind of float switch or an inclosed type may be employed. Figs. 6 and 7 show the wiring for automatic control of single- and three-phase motors respectively.

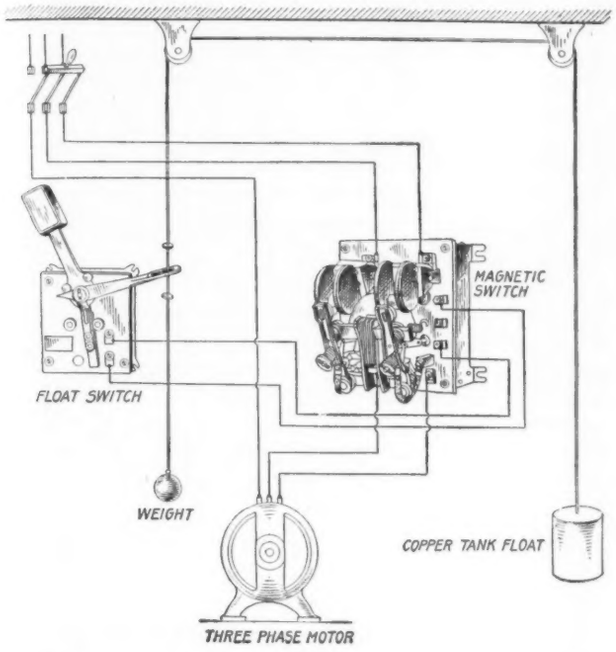


FIG. 7. WIRING OF AUTOMATIC STARTER FOR THREE-PHASE MOTOR

Pumps or compressors operating on closed systems are controlled in a similar way, the automatic starter being actuated by a pressure-regulated switch instead of a float switch, as shown in Fig. 8.

House pumps are required in all buildings where the city water pressure is not sufficient to supply the upper floors. These pumps are not required at all times, but only when the demand made on the system lowers the pressure maintained. To do this in the most economical and best way, automatic control of the starting and stopping of the pumps is necessary. The pressure requirements are thus always maintained. Fig. 9 shows two of three triplex house pumps in the Continental and Commercial National Bank Building, Chicago. These pumps are driven by 20-hp., 220-volt, direct-current motors automatically started and stopped by the three automatic

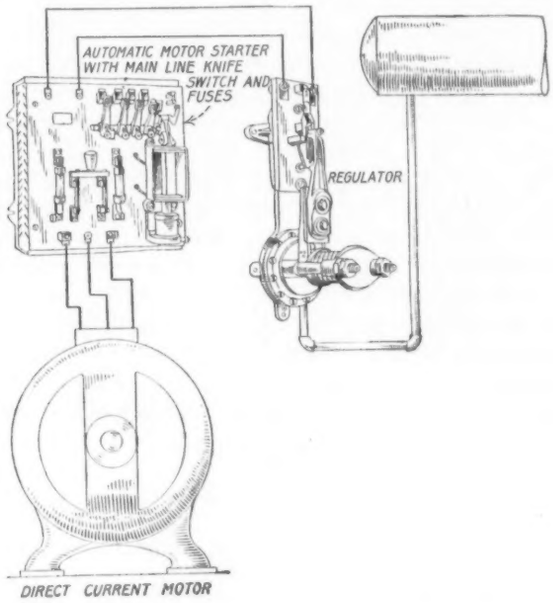


FIG. 8. WIRING AND CONTROLS FOR STARTER FOR DIRECT-CURRENT MOTOR

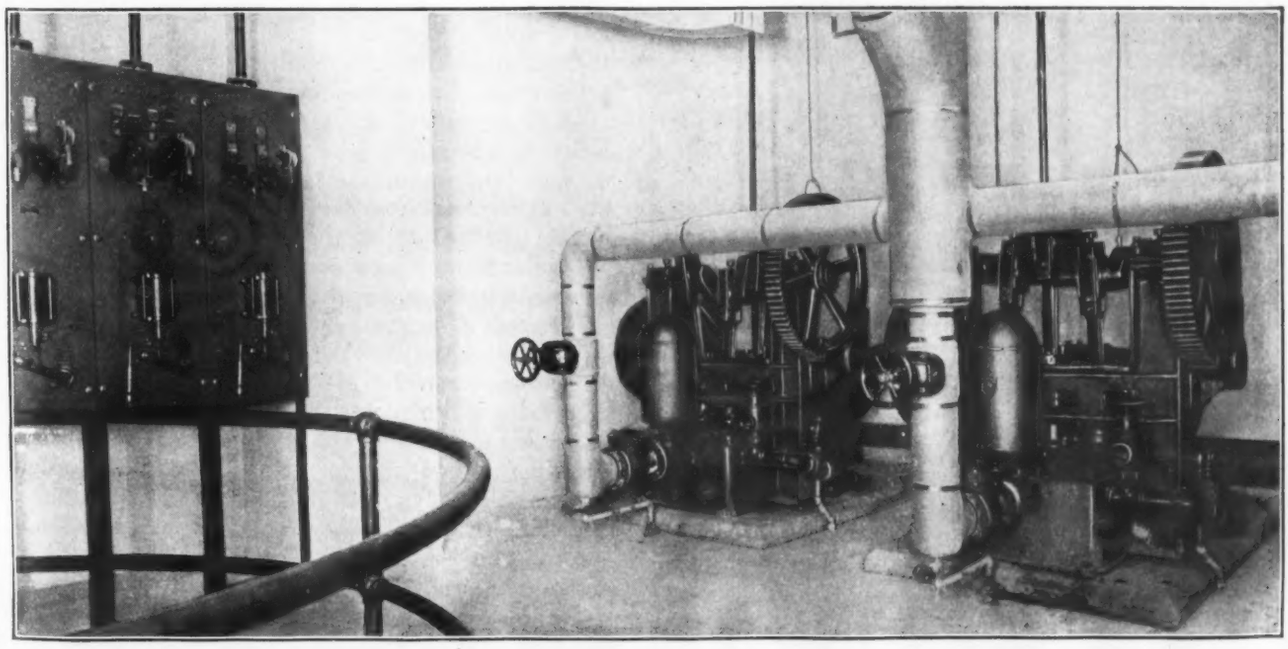


FIG. 9. TWO OF THREE ELECTRICALLY CONTROLLED HOUSE PUMPS IN OFFICE BUILDING

First, one is cut in, then if the demand increases, another is started, and so on until the demand is met

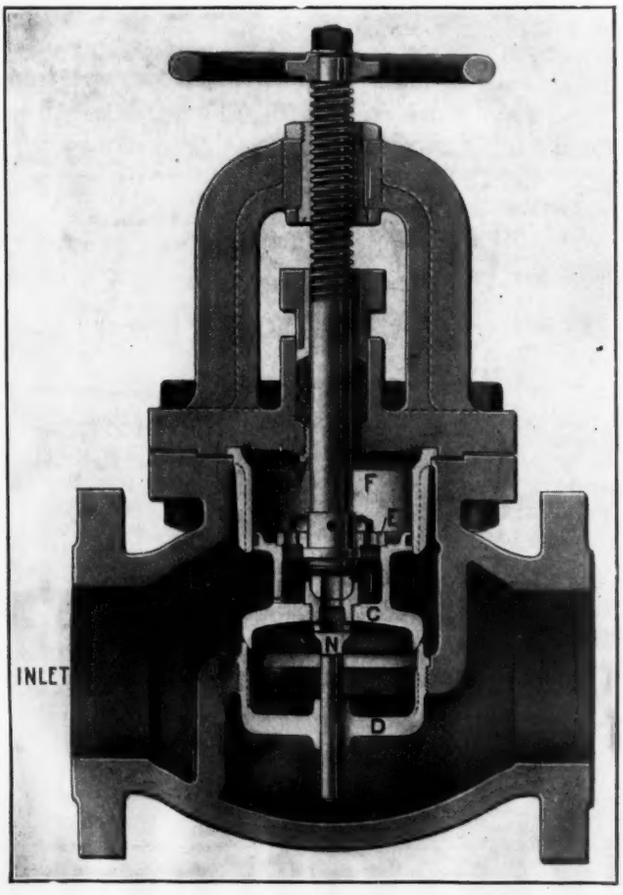
controllers shown on the panel. This equipment is arranged so that when the first demands are made, one motor is set in operation. If the demands of the service are greater than can be cared for by one pump, the second one is put in service and the third also, should it be needed. A pilot arrangement on the controller panels makes it possible to have any one of the three put in service first, followed by the others, thus dividing the work equally for a given period.

In the case of the automatic fire-pump controller any decrease in the pressure on the sprinkler system due to opening of a sprinkler head or to valve leakage causes the pump to be set in motion until the pressure supposed to be maintained in the system is again reached.

Similar machines, as vacuum cleaners, compressors and blowers, are also controlled automatically or by a push-button switch closing the automatic starter solenoid or magnetic circuit in the same way that a float switch or pressure regulator does. In buildings tenanted by dentists and physicians compressed air is usually furnished by compressors located in the basement and automatically controlled by pressure regulators and automatic motor starters, to keep a suitable pressure on the system regardless of the demand.

Lunkenheimer Balanced Throttle Valve

The balanced throttle valve illustrated herewith has been designed to operate with ease and with efficiency, combined with durability. When the valve is in place the steam enters above the disk, otherwise the value of the bypass is lost. With the valve closed pressure enters the balancing cylinder past the piston ring and through the drain hole in the bottom of the disk cylinder. As a result, the pressure above the disk is equal to that in the inlet of the valve. This pressure aids in keeping the disk tightly sealed, and it is relieved by the bypass *I*, the opening through which is covered by the bottom of the stem when the valve is closed. When the hand-wheel is turned slightly, this opening is uncovered and the steam above the piston passes through the holes in the retaining ring *E*, thence through the hole in the by-pass disk and through the drill holes in the bottom of the main-disk guide stem *N;* this relieves the pressure above the piston while the valve is being opened and the arrangement prevents pressure above the disk during the opening of the valve.



LUNKENHEIMER BALANCED THROTTLE VALVE

The drain hole in the bottom of the disk cylinder is to relieve the condensed steam that may accumulate in the cylinder when the valve is connected in a vertical position. When the valve is in a horizontal position the water in the disk and in the balancing cylinders will drain past the piston ring. Both the main and the by-pass valves are operated simultaneously. Provision is made for regrinding the seating surfaces of the main seat and disk seating surface.

This valve is manufactured by the Lunkenheimer Co., Cincinnati, Ohio.

Long Chances with the Portable Engine

BY LOE ADDY

The operation of a portable engine is not a very angelic occupation, and at times it would seem that there must be a destiny to guard the operators from misfortune.

Upon one occasion, while overhauling a second-hand sawmill outfit, a wooden connecting-rod was used as a template for a new rod and was left on the engine when the workmen left the mill on Saturday evening. The next morning the owner, anxious to try his new engine, got up steam, turned it on and gave the flywheel a whirl. The wooden connecting-rod broke and the crosshead drove the stuffing-box gland through the cylinder head.

The engineer of a threshing outfit fed vinegar into the boiler at the rate of about six gallons a day for several days. It was supposed to prevent the foaming of the bad water taken from ponds and muddy copperas streams. The engineer said that the boiler needed blowing down, but he had twisted off the stem of the blowoff valve. The boiler had not been washed out in weeks. Its internal condition can better be imagined than described.

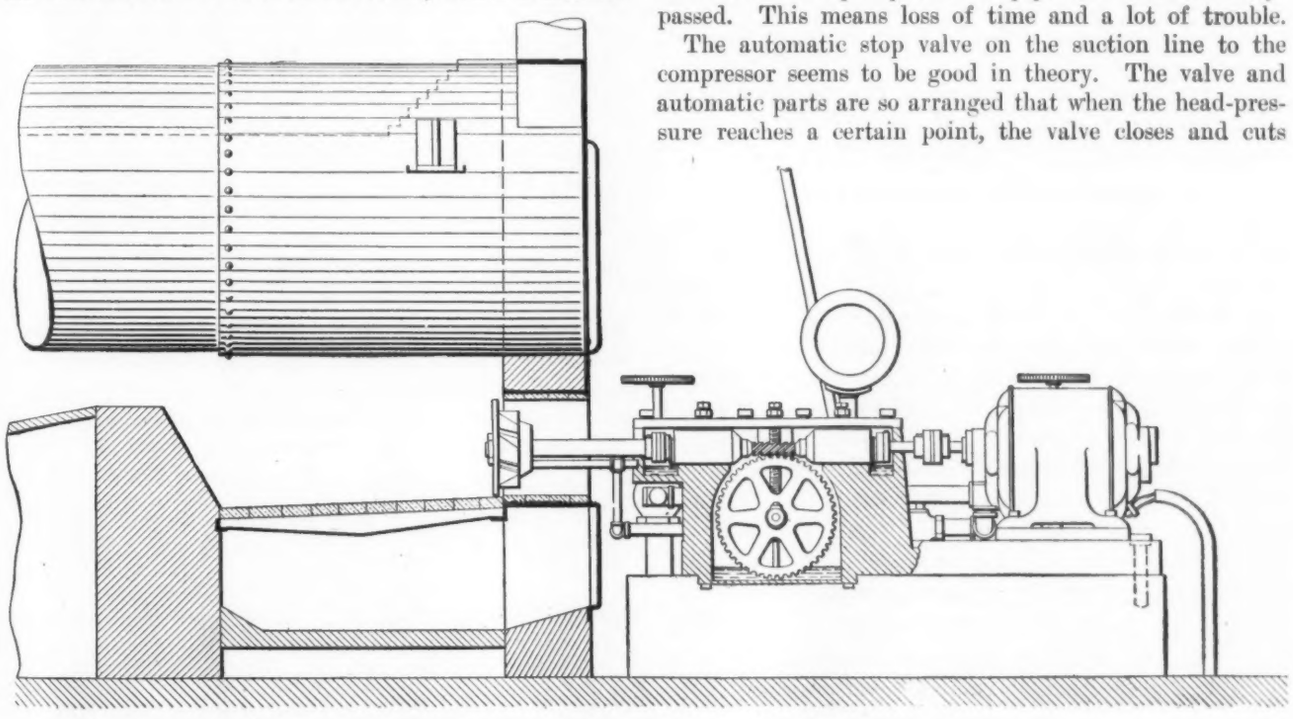
The speed of the sawmill engine was controlled by a lever bolted to one of the arms of the governor, from which the belt was removed. A wire attached to the end of this lever extended to a wooden lever within reach of the sawyer, thus furnishing means for shutting off the steam. When the wire was released the balls dropped by gravity, giving a full head of steam. The lever was secured by being hooked behind a nail in a post, to be released when the power was needed. It can readily be imagined about how sensitive the control was. They certainly placed great confidence in that wire and nail; for if the lever became unhooked or the wire broken, or even if the engine moved forward a trifle on its foundation, it would run wild under a full head of steam.

There certainly is no machine called upon to operate under as many trying conditions as the traction engine of a threshing outfit. A stationary engineer would hardly care to operate a unit under such conditions.

While descending a hill the furnace door is usually opened and perhaps the fire damped in order to protect the crown-sheet, which now has no water over it. At times on a short hill this precaution is not taken, and when level ground is reached the water comes surging back over the heated plate; yet, it is comparatively seldom that an explosion occurs. There are occupations more monotonous than that of the engineer of a traction engine.

Rotary Crude-Oil Burner

The rotary crude-oil burner illustrated herewith is manufactured by G. E. Witt Co., 862-864 Howard St., San Francisco, Calif. The principal feature is the placing of the burner on a horizontal shaft in front of the furnace, away from the heat, the air passing through it carrying the heat toward the back of the boiler, which overcomes



ROTARY CRUDE-OIL BURNER APPLIED TO A RETURN-TUBULAR BOILER

trouble from overheating. The burner is driven by a motor, and the device is self-contained. With the exception of the burner, all of the apparatus is outside the furnace.

This burner is suitable for boilers of small capacity, and is noiseless in operation. It has also been applied to boilers up to 140-hp. capacity, which demonstrates its wide range of application for both high- and low-pressure work.

Peripheral Speeds—As compared with the 38 ft. per sec., which is considered the limit in safe speed for a cast-iron flywheel, some of the peripheral speeds attained by the disks of steam turbines are striking. In a paper presented to the Manchester Association of Engineers, R. F. Halliwell says: "The highest peripheral speed which it is possible to employ is probably found in the 300-hp. DeLaval turbine, in which, with a 30-in. wheel running at 10,000 r.p.m., a velocity of over 1300 ft. per sec. is reached."

Ammonia Compressor Alarm

BY G. A. ROBERTSON

There has been considerable comment recently among refrigerating engineers as to the proper manner of installing relief valves or other similar devices to guard against serious accidents from excessive head-pressure in the refrigerating system.

Some have located a relief valve in a bypass line between the suction and discharge lines of the compressor, and there have been a few installations of automatic suction stop valves. Both of these methods have features that are undesirable. The relief valve installed in the bypass between suction and discharge lines, is set so as to let ammonia gas in the high-pressure side pass to the low-pressure side of the system, when the head pressure for some reason has increased to an undesirable point. When this valve has been lifted off its seat once or a few times, it is almost sure to leak. In order to inspect it, guard valves would have to be installed, which are undesirable, or the engineer would have to shut down and pump out the pipe lines that were bypassed. This means loss of time and a lot of trouble.

The automatic stop valve on the suction line to the compressor seems to be good in theory. The valve and automatic parts are so arranged that when the head-pressure reaches a certain point, the valve closes and cuts off the supply of ammonia gas to the compressor. There is some doubt as to whether the valve would respond when needed, since it is likely to stand for a long time without operating.

The writer desires to call attention to an alarm installation for the compressor. An ordinary ammonia relief valve (about 1-in.) is placed between the cylinder and the guard valve of the compressor, and the outlet connected to a ½-in. whistle fifteen or twenty feet from the machine. The valve is set to blow at 25 or 30 lb. above the usual head-pressure. Just as soon as the pressure reaches this point the whistle blows and gives warning. Should the machine be started with the guard valve closed, the whistle gives warning immediately. The operator could then stop the compressor in time to prevent an accident.

Some Notes on Fans*

By A. A. Potter and S. L. Simmering

SYNOPSIS—Rules and approximate equations for the capacity and cost of fans and blowers.

For the production of artificial draft use is made of chimneys, fans, blowers and steam jets. Under ordinary conditions a chimney 125 ft. high will give a draft of about 0.75 in. of water, or about 0.43 oz. pressure, and a chimney 250 ft. high will give a draft of about 1.5 in. of water, or 0.87 oz. pressure.

A chimney, once built, is limited in its capacity, whereas a fan may ordinarily have a range of pressure from 0.25 oz. to 4 oz., depending on the speed at which it is operated. This range of draft pressure makes it readily possible to meet any overload which may be suddenly demanded of the plant. A combination of the natural or chimney draft and forced draft is frequently used. The chimney draft in this case is made sufficient to overcome the resistance to the flow of the gases due to the flues, passages and chimney walls, while the draft produced by the fan is sufficient to overcome the resistance to the air in passing through the fuel bed and also to supply the necessary air for the combustion of the fuel.

Air Required for Combustion

If the coal burned consisted of pure carbon and perfect mixing were possible, about 12 lb. of air would be needed for every pound of fuel burned. As a general rule, however, under actual operating conditions about 18 lb. of air is required per pound of coal. The volume of one pound of air at 32 deg. F. and atmospheric pressure is approximately 12.5 cu.ft.; hence, the total volume necessary at this temperature to burn one pound of coal is about 225 cu.ft. For any other temperature t the volume becomes,

$$\frac{(460 + t)\ 225}{492}$$

If

w = Weight of coal burned per hour;
t = Temperature at which the air or gases enter the draft-producing apparatus;
A = Volume of air in cubic feet per minute;

then

$$A = \frac{225\ w\ (460 + t)}{60 \times 492} \text{ or, } A = wk$$

The values for k for different temperatures are as follows:

t	k	t	k
60 deg. F.	3.96	300 deg. F.	5.79
80 deg. F.	4.11	400 deg. F.	6.55
100 deg. F.	4.27	500 deg. F.	7.32
200 deg. F.	5.03	600 deg. F.	8.09

The forced-draft apparatus would handle the air at a temperature of about 80 deg. F., and an induced-draft apparatus at about 550 deg. F., if no economizer were used. Hence, from the above the following approximate rules are deduced:

Rule 1—The cubic feet of air to be supplied per minute by a forced-draft apparatus is equal to four times the number of pounds of coal burned per hour.

Rule 2—The cubic feet of gases handled per minute by the induced-draft apparatus when no economizer is used, is equal to eight times the number of pounds of coal burned per hour.

Capacity and Cost of Fans

Table 1 gives the capacity of fans in cubic feet per minute corresponding to pressure in ounces per square inch for three different speeds. The approximate cost of the fan is also given in each case, and the size is expressed as the diameter of the fan in inches. For sizes of 18 to 48 in. the relation between cost and size is very indefinite, but the approximate cost in dollars, C, may be represented by the equation,

TABLE 1. CAPACITY AND COST OF FANS AND BLOWERS

Diameter, In.	R.p.m.	Pressure, in Oz.	Cu.Ft. per Min.	R.p.m.	Pressure, in Oz.	Cu.Ft. per Min.	R.p.m.	Pressure, in Oz.	Cu.Ft. per Min.	Cost in Dollars
18	600		2,210	900		3,150	1200		4,080	10
24	500		4,220	800		6,800	1100		9,350	12
25	450	0.25	1,580	907	1.0	3,170	1845	4	6,450	63
30	450		6,384	675		9,650	900		12,846	14
31	365	0.25	2,560	731	1.0	5,100	1488	4	10,390	67.50
36	400		9,600	600		14,600	800		19,200	17
42	270	0.25	5,338	540	1.0	10,670	1080	4	21,390	90
42	350		14,700	550		22,300	750		30,900	20
48	300		18,300	500		30,500	700		42,700	25
54	250		22,100	450		36,000	600		48,500	65
60	189	0.25	10,250	378	1.0	20,490	758	4	41,120	157
60	225		24,750	375		41,000	500		55,000	85
72	200		34,000	300		51,000	400		68,000	120
72	157	0.25	14,840	314	1.0	29,650	631	4	59,490	247.50
84	135	0.25	20,200	270	1.0	40,360	541	4	81,160	315
96	118	0.25	25,060	236	1.0	50,280	473	4	100,446	405
120	94	0.25	37,920	188	1.0	75,790	378	4	152,000	563
132	86	0.25	46,260	172	1.0	92,430	344	4	185,300	630
144	78	0.25	54,400	158	1.0	108,740	316	4	218,080	675

Turbo-Blowers

Size, In.	Boiler Hp.	Cost, in Dollars
15	175	150
18	300	175

$$C = 0.5\ D + 1 \text{ (lower limit)}$$

in which D is the diameter of the wheel in inches. For sizes of 25 to 60 in. the approximate cost is

$$1.66\ D + 21 \text{ (upper limit)}$$

and for 60 to 132 in.,

$$6.94\ D - 266$$

Effect of Flue-Gas Temperature

Calculations based on a temperature of 60 deg. F. would not be correct for temperatures of 400 or 600 deg., which are common in induced-draft systems. The principles upon which the necessary corrections are made are as follows:

When air is heated it expands, and the weight of a given volume varies as the absolute temperature. The necessary fan speed to produce a given pressure is proportional to the square root of the absolute temperature. The power required to drive a fan varies as the velocity of the flow when the pressure and the outlet area remain constant.

The effects of flue-gas temperature on the speed and capacity of fans are shown in Table 2.

TABLE 2. EFFECT OF FLUE-GAS TEMPERATURE

Temperature of Gases, Deg. F.	Factor for Proportional Volume at 60 Deg. F.	Factor for Increase of Speed	Factor for Increase in Horsepower
400	0.77	1.28	1.28
500	0.73	1.35	1.35
550	0.725	1.38	1.38
600	0.70	1.42	1.42

*Copyright, 1915, by A. A. Potter, Dean of Engineering, Kansas State Agricultural College, and S. L. Simmering, Instructor in Steam and Gas Engineering, Kansas State Agricultural College.

Editorials

Burning Low-Grade Fuel

The leading article of this issue should be read with more than passing interest. It tells of a moderate-sized plant in which, by simply changing the boiler-furnace equipment, there resulted a saving amounting, in round numbers, to thirty-five thousand dollars per year.

Under the former conditions coal fresh from the mine was burned in the boiler furnaces of the Bessemer Coal & Coke Co. This fuel had a marketable value of about one dollar per ton and one hundred tons was burned every twenty-four hours.

A five to six-in. layer of bone exists between the coal deposits, and it cost from three to four hundred dollars a month to remove this bone from the mine. It had no value as a fuel. When attempts were made to burn it the result was most unsatisfactory.

Six of the power-plant boiler furnaces were recently equipped with mechanical stokers, and now this fuel, that cost something like forty-two hundred dollars a year to remove, is burned under the boilers, with a saving of the run-of-mine coal formerly consumed and a saving in the bone-removal charge. Furthermore, the boiler-room force has been reduced from ten to six men for the twenty-four hours.

This bone contains between thirty and forty per cent. ash content and averages about eighty-five hundred British thermal units per pound as fired. With this fuel and the stoker equipment, the boilers have been operated at one hundred and seventy-five to two hundred per cent. of rating.

There is a lesson in this for the plant that might burn low-grade fuel and does not, and it shows that intelligent investigation into furnace conditions can result in a surprising saving in operating expense as well as, in this instance, the burning of a fuel that was considered worthless. Instances are rare where such great savings can be effected, but it always pays to be vigilant. These people were doing their best under the old conditions, but some one thought of improving the conditions.

Stokers for Locomotives

The summary of a report by D. C. Buell before the annual meeting of the International Railway Fuel Association appearing elsewhere in this issue is interesting as indicating the latent possibilities of the locomotive stoker. What will perhaps come as a surprise to many is the fact that the fundamental reason for the application of stokers to locomotives is that maximum capacity of the engines can be obtained with more certainty under trying conditions than under hand-fired conditions, even with two firemen to a cab. Formerly, the argument for locomotive stokers emphasized the greater economy over hand-firing and the elimination of smoke, just as did the early statements enumerating the advantages of stokers for stationary boilers. Experience seems to be proving that it is the greatly increased capacity possible with a minimum of labor that is the sum and substance of the superiority of stokers for locomotives, just as it is for stationary boilers.

Another quite natural characteristic to be expected is that locomotive-stoker manufacturers have in most, if not all, cases had to adapt their product to the locomotives, but were never frequently favored by designers considering how the locomotive could be made to more favorably receive the stoker. The stoker builders' experience parallels that of the early steam-turbine manufacturers. The turbine, of course, ran too fast, and it was for a long time known that its speed could not be reduced without commercially impossible sacrifices in economy, before builders of "the other end," meaning the driven machine, made serious efforts to adapt their products to turbine speeds.

Engineers may be progressive and radical as they wish, but the fruits of their labors find commercial application only as fast as conservative business permits.

By the way, what is the state of the art regarding stokers in marine practice? Indications are that marine men are going to be true to tradition and not adopt the stoker until its success has been absolutely assured everywhere else.

Welded Pipe Work

The first notable change in steam mains for power plants was the doing away with the double header—the elimination of that emergency steam container considered so indispensable when the header in service developed a serious leak. Plant designers omitted the second header only after experience demonstrated that if the pipe material was sound and the fitting properly done, leaks or steam-main troubles serious enough to warrant cutting out the entire header would not occur. The next advance comes in the reduction of the number of flanges on headers and in mains. A steam leak is not only an eyesore, but makes a sound that disturbs your conscience, drops water down the back of your neck and, unfortunately, costs money. As the leaks invariably occur at the flanges, why have more flanges than necessary?

Autogenous welding has been a great help to various industries, and there are few places in the power plant where it does more lasting good than it does when applied to the heavy piping. As the writer of the article on this subject, appearing elsewhere in this issue, remarks, header and pipe may be made up in lengths limited only by shipping and erecting facilities. In the case of headers the welded header is not only lighter, being more easily supported than a flanged one, but it costs less.

Welding is also proving well suited to pipe-coil construction. Coils are usually inclosed in a shell or vessel, and if a leak occurs, it must be quite serious to be quickly discovered. Welding makes it possible to make up exceedingly long coils with no joints except at the inlet and outlet ends, which are outside the shell containing the

coil. Where special bends are needed, the welding process sometimes offers an easy solution to what might be a troublesome problem both in construction and erection.

Quite naturally, considerable apprehension was felt in the early days of the application of welding to high-pressure piping. Many will not permit its application to boilers, and it may be expected that extensive experience with welded steam pipe or the wide dissemination of the results of many destruction tests on welded boilers, will be necessary before the torch will find a field of usefulness on boilers other than cutting old ones into junk and facilitating their removal and transportation to the pile. In this respect the destruction tests described in the article referred to are interesting and encouraging.

Recent License Legislation in Massachusetts

As the smoke of the recent heated discussion of license legislation rises above the good old Commonwealth of Massachusetts, an amended license law is seen to have resulted. Supervision of boilers, inspections and licensing remains in the hands of the boiler-inspection department of the District Police.

Before considering this last amendment a little history of the license-legislation tendency in the Commonwealth during the last few years will assist in more clearly comprehending the causes back of the recent change.

Section eighty-two of the original law stated that "Licenses shall be granted according to the competence of the applicant . . ." Again, Section eighty-one rules that ". . . he shall receive, within six days after examination, a license graded according to the merits of his examination, irrespective of the grade of license for which he applies."

In this law nothing was said about a man holding one grade of license being compelled to serve a specified time before he could apply for one of a higher grade. It was in 1911 that the desires of many for a time-service clause found a place in the law which, as then amended, made it necessary for applicants to have served specified times under lower-grade licenses before they could lawfully apply for licenses of a higher grade.

That part of Section eighty-two relating to special licenses seems to have been objectionable to many manufacturers, particularly those whose plants were run most of the time by water power, but which had steam power for low-water periods or for emergency purposes. The law allowed an engineer a special license for a particular plant, "provided, however, that no special license shall be granted to give any person charge of, or permission to operate, an engine of over one hundred and fifty horsepower." This same section also allows a man holding a second-class license ". . . to have charge of and operate a boiler or boilers, and to have charge of and operate engines, no one of which shall exceed one hundred and fifty horsepower, . .

It is seen that a plant having an engine or engines of more than one hundred and fifty horsepower and operated most of the time by water power was compelled to have a first-class engineer in attendance. This, it seems, was the thorn in the manufacturer's side. So this year the much-talked-of House Bill No. 1111, widely circulated with a form letter urging those approving to request their representatives to support the bill, was presented. This bill aimed to overcome the special-license objection by providing that a person desiring to have charge of a particular plant might, on examination, receive a third-class license, which, according to Section twenty-one of the bill, allowed "the holder to have charge of and operate any particular steam engine or engines." The firemen's license would have covered the boiler or boilers.

So much was asked for in Bill 1111 that the proponents suffered the experience of the dog that stopped to look at himself while crossing the brook with a bone in his mouth. A compromise was effected in which the manufacturers are allowed to have engineers holding special licenses to operate plants with engines of any capacity, so long as the plants are run by water power exclusively during the major part of the year.

We see no objection to this amendment, as it does not make these plants more dangerous to public safety than before, provided, of course, that the examiners do their duty. It should ease the strained relations between employers and engineers.

The Plumber and Us

Can it be that the plumber intends encroaching upon the domain of the power engineer?

From a recent issue of the *Plumbers' Trade Journal* it is gathered that there is a growing belief among master plumbers that their future "resembles a broad path of progress leading to the top of contract hill, the apex of which will be reached when the master plumber handles not only the plumbing, but the heating, ventilating, power plant, lighting, elevators, sprinkler equipment and refrigeration work as well."

These are high-sounding words, my masters, and would seem to indicate that the "apex" alluded to is, just at this minute, impossible of discernment. It is reasonable to say, however, that the plumber of today—once a worker in lead and popular mainly as a medium for threadbare witticism—has in many directions so broadened his one-time field of endeavor as to include much inter-related work. He has, for example, become "familiar with the radiant warmth of the heating system"; he is already attracted "toward the power handled by the little copper wire"; his association with boilers has privileged him to talk intelligently on pounds pressure and B.t.u., and his anxious inquiries in his trade papers show his interest to be greatly beyond the use of the soldering iron and the pipe cutter. Furthermore, he informs us that, as "consolidation is the modern trend in every line," he feels that in the future he will "handle" a large, thick slice of the mechanic arts—or cease to exist!

A most confident and ambitious person is the plumber man, as no one will deny. He insists that the sanitary wholesomeness now enjoyed by the public is mainly owing to his efforts, and that in due time his trade will be a profession.

As to his desire to annex the territory, to occupy the terrain, of the powers now controlling the power-plant, the heating and ventilating, refrigeration and elevator domains, one is inclined to the opinion that the plumber in his present state is vainly striving to separate from its main body a huger portion than he can successfully masticate.

Correspondence

Putting Crank Disk on Shaft

On page 654 of the May 11 issue is a letter requesting information on tightening a loose crank without removing it. I believe that it is almost impossible to do this and make a safe job, because after the engine has been run for some time with a loose disk it will not only hammer the hole out of true, but will also deface the surface of the shaft, so that the disk, if made tight, would be out of line. Consequently, the crank would not be true.

There are several methods of tightening a disk, all depending on the conditions, material available and tools at hand. I know of one case where the disk was riveted onto the shaft, and another where the shaft and the disk were drilled, reamed and tapped to receive tapered bolts at several points on the shaft. In the latter case the disk was out of line, although it was run for some time by leaving the crankpin brasses keyed slightly loose. This caused a slight pound, which increased until the tapered bolts became loose and hammered, so that they could not be removed. Eventually, a new shaft and crank disk had to be purchased. So it is cheaper in the long run to put on the new disk first and see that the shaft end is in proper condition before the disk is put on, or it may be necessary to rig a turning tool and means for revolving the shaft to true up the battered end before the disk is fitted.

The cause of many a loose crank disk is in the heating before it is placed on the shaft. In most cases where the job is to be done a long way from the shop, the disk is blocked up on brick supports with a fire beneath it. In many instances the fire is too hot and the flame will concentrate through the hole in the center of the disk, causing the edge around the hole to become very hot, perhaps a bright-red heat before the rest of the disk shows signs of turning red at all. This is where the mistake is made in judging the temperature which the metal should stand at the edge of the hole without ruining its contracting quality, causing it to crush together or stretch when the shaft is expanding from the heat of the disk. This is owing to the fact that the outside edge of the disk is usually much cooler and does not expand as the shaft does, and the metal around the hole, being hotter, is compressed, thus causing a misfit when cold. The fire should be a slow one and very even, and a cover should be placed over the hole to prevent the heat concentrating on the inner surface and edges. The disk should then heat gradually and evenly to a very dull or cherry red and no hotter. Even though it may be a little harder to draw on the shaft, it will contract to a good tight fit when cold.

The space in which the metal is compressed while hot extends back to a circle about one inch larger than the bore for the shaft and the pin cannot be made tight without removal and refitting, often by refitting and reshrinking over a shim or bushing. When the keys are not the proper size to fill the keyways in the shaft and hub, small steel strips should be made to fit on top of them to prevent the key from working up or down and wearing out the sides of the slots, which will happen with a loose disk or wheel, though it may not be noticed at the front or face of the hub.

I had an experience with a crank disk that had been overheated at the bore. This was to be put on a 650-hp. cross-compound engine just being erected. The job was a time contract, and the engine had to be ready or penalties would be exacted. The time was short and it was urgent that the disk be put on before dark, as there was no light to work by. It was heated over a roaring hot fire, and overheated at the center, but it went on nicely. The engine was assembled, tightened up and adjusted and ran smoothly with normal load. When the overload was put on, however, the trouble was discovered—the low-pressure disk had loosened, the bore had battered about $^1/_{64}$ in. out of true, and one would have thought there was 4 ft. play judging from the hammering before the engine could be stopped. A new disk was sent from the shop, but in the meantime, to avoid loss of time and penalty, it was decided to try calking the boss of the hub around the shaft. This held the disk tight enough for normal load, but only contracted the metal in the hub to a depth of ½ in. or less in the 6 in. of the disk's thickness and would have given way again as soon as load enough was put on the engine to bring extra strain on the disk. Greater precaution was taken in heating the next disk and it went on the shaft nicely and gave no trouble.

R. A. Cultra.

Cambridge, Mass.

Replying to Mr. Jensen's letter, it was a mistake to have the keys fit tight sideways. If he will pull these and substitute keys made with side clearance, which are tight top and bottom, driving home with a 20-lb. sledge, he will have no further trouble. In preparing the new keys have them made with heads to facilitate pulling during the process of fitting, which will require some care. After driving home, the heads can be cut off. The keys, being tight at the top and bottom, pull the crank to practically a forced fit on the opposite side of the shaft.

John F. Hurst.

Louisville, Ky.

I would suggest that Mr. Jensen take out the old keys and replace them with new ones properly fitted. Do not try to use up the old keys by placing liners in with them, as this is only a makeshift.

Making keys grip on the sides of a keyway is a method much used by machinists in this country. Why, I do not know. The proper way to fit a key is to have it large enough so that when first driven in it will go only about three-eighths of the way. It is then driven out and the high spots filed off. The bottom of the key does not require to be filed, and the sides should merely touch.

Repeat the operation, driving in and out until the key reaches within ¾ in. of being home, then use a heavy sledge for the final drive. The key is driven flush. Should any part project, chip off and file. If it has been properly fitted there will be no more trouble.

This is the method I have used on the wheels of locomotives after they had been shrunk on, and were not beaded over. The sketch did not show whether the keyway is extended beyond the crank disk to allow the driving out of the keys, but if not and there is room, it will be necessary to do so, just enough to allow the key drift to enter.

C. SWORD.

Cohoes, N. Y.

In regard to Mr. Jensen's loose crank disk, I would advise drilling and tapping five tapered holes, half in the disk and half in the shaft, then screwing in tapered bolts very tightly. Cut these off flush and peen the shaft evenly all around so as not to throw it out of line. Take time and pains with this job.

B. C. WHITE.

Yonkers, N. Y.

[Letters covering many of the points mentioned were received from William Braunbeck, of New Brighton, Penn., and James E. Noble, of Toronto, Can.—EDITOR.]

Cost of Handling Ashes With Steam Vacuum System

In the article describing the boiler plant of the Union Brewing Co. in St. Louis, which appeared in the May 18, 1915, issue of POWER, the paragraph on page 665 referring to the cost of handling ashes is rather ambiguous. We are in a position to know that the 10 to 12c. was intended as the total cost per ton, including the charge for steam. A casual reading might give the impression that the 10 to 12c. included only the fixed charges, such as depreciation, interest, etc. Since the article was written we have had an opportunity to inspect one of our systems that has been handling ashes at the rate of 60 tons per day, and from the results of this inspection we are confident that the main pipe will handle at least 100,000 tons before it is ready for the scrap heap. Taking a small plant producing 10 tons of ashes per day, or 3000 tons per year of 300 days, as a typical example, we have found that the cost for repairs has amounted to $8.50, or $0.00285 per ton. Figuring the initial investment at $1000, interest at 6 per cent. would amount to $60 per year, or 2c. per ton. At the rate of 3000 tons per year, the equipment would last for 33⅓ years, or in round numbers, say 30 years. The depreciation then could be figured at 3⅓ per cent. and this proportion of $1000 amounts to $33.33 per annum, or $0.01111 per ton. Summing up, the charges for upkeep, interest and depreciation amount to $0.03396, or approximately $0.034. To this must be added a charge of about 6c. per ton of ash for steam, making a total of $0.094 per ton, which figure may be compared to the 10 to 12c. given in the article.

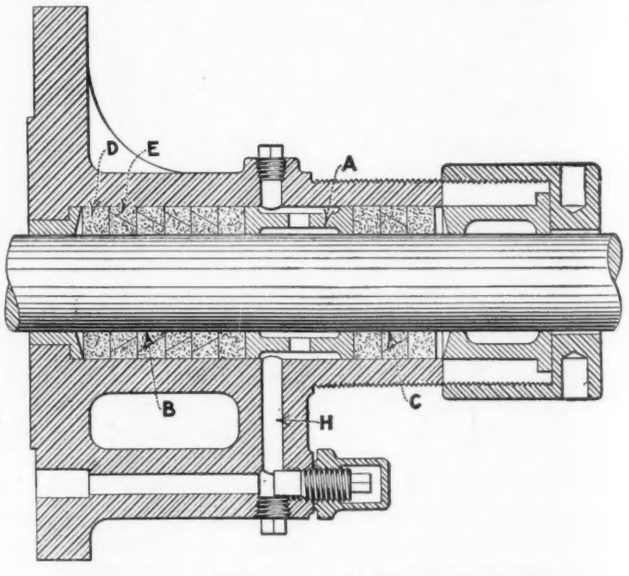
Ordinarily, in a plant handling 10 tons of ashes per day, no additional labor would be required to operate the vacuum system, but to meet all contingencies the following comparison may be of interest: Where 10 tons of ashes per day are handled by hand over a distance of 100 ft., the cost is rarely below 20c. per ton, or a total cost of $2 per day. Assuming this charge per ton for wheelbarrow conveyance and also as a labor charge for the vacuum ash-handling system, which would handle the total amount of ashes in 2 hours, the charge against the latter would be only 40c. as compared to the $2 given above. Adding the $0.94 for the other items entering into the cost of the vacuum system gives a total of $1.34 for the 10 tons. Without allowing anything for the equipment that would be needed in hand conveyance, the saving is 66c. per day, or $198 per year of 300 days. On this basis the earning is nearly 20 per cent. on the investment, so that in a little over five years the equipment would pay for itself. At the end of this time the saving would be much larger, as the interest and depreciation items would have been eliminated.

R. H. MILLER,
Girtanner-Daviess Engr. & Contr. Co.

St. Louis, Mo.

Ammonia Stuffing-Boxes

The ammonia-pump piston rod is usually made of hard hammered steel and frequently separates from the steam piston rod. The reason for this construction is apparent. The pump piston rod wears rapidly, and if the machine



STUFFING-BOX OF AMMONIA COMPRESSOR

is fitted with a two-piece piston rod the pump rod may be replaced when worn without disturbing the steam rod.

A long stuffing-box, as shown, is divided into two compartments by the gland *A*. In packing an ammonia stuffing-box care must be taken that this gland is over the port *H*, leading to the suction of the pump. With a box constructed in this way the first set of packing *B* is subjected to cylinder pressure. Any leakage past this packing is reduced to suction pressure at once, thus the second set of packing *C* is only subject to this pressure. The port *H* should always be kept clear. This port can be closed by means of the plug and the space about the gland filled with oil to act as a seal, if desired.

When the stuffing-box is properly packed with alternate plain (*D*) and sectional (*E*) rings, as shown in the sketch, there is no necessity for subjecting the packing to

great pressure to keep the box tight. If the rod is worn it should be removed at once and turned true, or if this is impracticable a new pump piston rod should be installed.

It is impossible to properly pack the stuffing-box when the rod is badly worn.

THOMAS J. ROGERS.

Brooklyn, N. Y.

Gasoline Engine Run on Natural Gas

In answer to the inquiry of Mr. Gawthrop as to the feasibility of using an automobile engine on natural gas, I believe the results would not be satisfactory.

Last year in Texas, I ran upon a similar proposition. In this case the engine was taken from an old Buick car and was belted to a 15-kw. alternating-current generator. The engine was provided with a Pickering governor, bolted to the crank case and belt driven from the crankshaft. The governor stem, through levers, handled the gas and air butterfly valves. We found that it was necessary to arrange the valve levers so that, for a given movement of the governor stem, the air valve moved through a greater angle than did the gas valve. This was owing to the fact that on light loads the mixture became too lean to explode if the two valves regulated to the same degree.

The outfit ran fairly well, although it was necessary to watch it constantly and it required far more attention than did the 100-hp. gas engine in the plant. The amount of lubricating oil used was excessive, as the engine, although in excellent condition, tended to heat up after a three- or four-hour run. While it was impossible to check the consumption with any degree of accuracy, it was the belief of the operators that the gas per horsepower was at least 50 per cent. greater than in the regular gas engine.

As regards the speed regulation, on a fairly steady load the lights did not flicker and the voltage fluctuation was small. However, when the load dropped off suddenly the engine would speed up considerably, in which case the engineer would run to change the gas-valve link rod, thereby bringing the speed back to normal.

No gasoline engine will burn natural gas economically unless means be provided to increase the compression, such as fitting new cylinder heads. If this is not done, the amount of gas used is excessive. For any given cylinder dimensions an engine will develop approximately five-eighths as much power on gas as on gasoline, in ordinary operation. Consequently, the 60-hp. automobile engine should develop about 50 hp. at 1000 r.p.m. or 37.5 hp. at 750 r.p.m.

Mr. Gawthrop, in using a 17½-kw. generator, would require not more than 27 hp. Therefore, his engine need never deliver more than 65 per cent. of its rated capacity. At this load he will do well to obtain a horsepower-hour on less than 25,000 B.t.u., or 50 per cent. more than a regular gas engine would use at this percentage of full load (17,000 B.t.u. at 60 per cent. load.) A standard-make gas engine at full load will ordinarily develop a brake horsepower-hour on 11,000 to 12,000 B.t.u. If the outfit develops 27 b.hp., the additional heat required would be 351,000 B.t.u. per hour, which, based on a six-hour run, would be 2,106,000 B.t.u. daily. Not knowing the gas used, one can merely estimate its heat content. Assuming 800 B.t.u. per cubic foot, the automobile engine will demand 2630 cu.ft. per day more than the gas engine. If gas costs 25c. per thousand cubic feet, the extra fuel consumption of the automobile engine would be about $240 yearly. Of course, the lighting load will vary, so that the 27 hp. will probably be the maximum rather than the normal load. Nevertheless, the gas consumption will be at least as much as given above, since on any smaller load it will be still more per horsepower-hour. Therefore, it would probably be cheaper to purchase a gas engine, thus also avoiding the worry, trouble and extra fuel expense that he will undoubtedly experience with his automobile engine.

L. H. MORRISON.

Fremont, Neb.

With reference to Mr. Gawthrop's inquiry, page 654, May 11 issue, as to the use of a gasoline engine on natural gas, I would advise him to increase the compression about 25 per cent. either by putting plates on the piston or cylinder head or by employing a new piston to fill up the extra clearance. Plates on the piston head are not satisfactory owing to the weight. He will need a heavier flywheel also. If operated without the above, and, as on gasoline, the engine will develop from 40 to 60 per cent. of its former power.

B. C. WHITE.

Yonkers, N. Y.

Uniform Size for Catalogs

I should like to call the attention of manufacturers and dealers to the desirability of uniform-sized catalogs. The writer, like many others, likes to file by subject, and catalogs are very awkward to handle as they are now issued. One large heating concern issues a number of publications, and no two of them that I have seen are of the same size.

This looks like a small matter, but filing catalogs for reference would be much more conveniently done if the advertisers saw the matter as it appears to the user of the catalogs.

LEWIS F. BROWN.

Winston-Salem, N. C.

The Storage Battery and Its Limitations

The storage battery as a power-plant auxiliary is looked upon by some engineers as objectionable, because of the constant and skillful care required. The writer believes, however, that there is no electric apparatus that responds so readily to good care as the storage battery, and it can be watched easily by means of a hydrometer and voltmeter, as well as by the gassing during overcharge. Where a battery set is properly installed in a clean and well-ventilated place, heated in the winter to approximately 70 deg. F., and is properly cared for and worked in accordance with its capacity, it will repay the owners in more ways than one.

The present lead sulphuric-acid battery appears to reach its all-around maximum usefulness on the 220-volt system, or less. Most batteries in power stations are installed for emergency or standby service and depend

mostly on ampere-hour capacity for maximum usefulness. To increase the voltage above 220 means increasing the number of cells, and proportionately increasing the cost to keep the ampere-hour capacity the same. Consider a 220-volt and a 550-volt railway system and a proposed 2000-ampere-hour battery. The initial cost of the former will be less than half that of the latter, which also holds true as to maintenance. In order to keep down the initial cost of the 550-volt railway battery, the ampere-hour capacity is often sacrificed, leaving a train of troubles behind that are not easily remedied, especially with increasing load. In cases where it is possible to shut down a few hours each night, a storage battery for lighting purposes and light loads can be made to pay for the investment by keeping the load factor higher on the generating set, with a saving in coal and oil and a chance for small repairs during shut-down periods.

BEN DAWSON.

Cedar Rapids, Iowa.

Broken Corliss Exhaust Valve

On our 42x60-in. Allis blowing engine, from some unknown cause the bottom exhaust valve broke at the eye where the stem fits in. We had no spare valves, and to avoid a loss of several hundred dollars a day, a rapid repair was necessary. The broken piece was clamped back

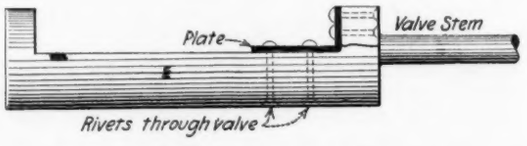


FIG. 1. EXHAUST VALVE REPAIRED

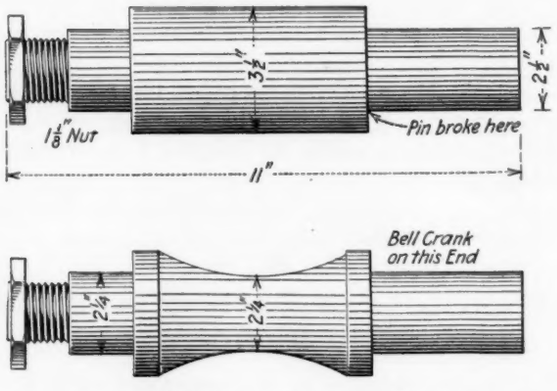


FIG. 2. DASHPOT PIN, SIZE REDUCED

in place temporarily, a plate was bent into the shape shown, and drilled and riveted to the valve. The stem was then put in and holes were drilled through stem and valve and countersunk. The parts were then riveted together and smoothed off to make a running fit, Fig. 1, and the engine was started five hours after the accident.

On a 96-in. low-pressure blowing engine with a Corliss valve gear a lot of trouble was caused by the breaking of the dashpot pins. Different kinds of material were used without success, the pins lasting from six weeks to three months only. A change was finally made, as shown in the illustration, Fig. 2. Instead of making the pin straight across, some of the metal was turned out, which made it much lighter and gave it a chance to spring a little. After this change, the pins lasted from six to twelve months.

FRED K. GINTHER.

Leetonia, Ohio.

Facing up Rubber Pump Valves

When pump valves become worn they have to be faced up or replaced with new ones. The usual way of facing by hand, using sandpaper on a block of wood having a true face, requires considerable work, time and sandpaper.

The pump I have in mind has 24 valves costing $1 each, so they cannot be thrown away when they begin to leak. The rig I use for facing the valves is made from a square block of wood held in the lathe chuck and turned down to the size of the disk, and the extreme end to the size of the hole in the center of the valve to act as a guide. Four brads, driven in and pointed so as to sink into the back of the valve, hold it from turning while facing. In this way old valves are made serviceable for a long time.

R. G. CURREN, JR.

Kittanning, Penn.

A Pipe Stopper

An arrangement used by plumbers for the same purpose as that described in the issue of May 25, on page 724, is made in the following way. It consists of a ¾-in. pipe with a long thread on one end, over which is screwed an iron washer about one inch smaller than the inside diameter of the pipe to be plugged. Next to this washer a cup leather is placed, then a smaller washer, and a ¾ locknut.

The outer end of the pipe is connected to the water service. When the stopper is inserted into the pipe beyond the riser and the water is turned on, the pressure will open out the cup leather and prevent any water passing it. A set of leather and iron washers for each size of waste pipe will make it possible to clear almost any line about the place.

JAMES E. NOBLE.

Toronto, Ont.

Removing Dents from Tanks, etc.

Frequently, tanks, pipes and floats of metal become dented, which is objectionable in one way or another, and the dent cannot be got at from the inside. There are two ways of getting rid of the dents; one is by heating and the other is by hammering externally. The former method is preferable for very thick tanks. The heat should be applied around the depression so that the metal on the borders will be heated and expanded, and then at suitable intervals the dented portion should be cooled. This will keep contracting and drawing the dented part back into place. An easier method for thinner articles consists of tapping around the edges of the dent with a light hammer, which will bring the dent out. Neither process is quick, but both are effective.

A. P. CONNOR.

Washington, D. C.

Inquiries of General Interest

Butt Joint with Single Cover Plate—For a boiler shell, what advantage over a lap joint has a butt joint with a cover plate on only one side?

T. H. R.

With a single cover plate, the cover behaves simply as an intermediate plate attached to the two main pieces by an ordinary lap joint, and unless the cover plate is of sufficient thickness to prevent its bending, a butt joint has no advantage over a lap joint.

Air-Supply for Ventilation of Assembly Rooms—What quantity of air-supply is regarded as adequate for good ventilation of assembly rooms?

R. G.

The requisite air-supply by ventilating apparatus will depend largely upon the character of building construction and the period for which the rooms are occupied. For ordinary conditions the average quantities recommended by authorities as a minimum quantity of outdoor air which should be supplied per room occupant per hour may be stated as follows:

For theaters, 1200 cu.ft.

For factories, workrooms, courtrooms and auditoriums, 1500 cu.ft.

For school and college rooms, 1800 cu.ft.

Reversing Eccentric with Same Angle of Advance—If the eccentric of an engine with direct-connected valve gear is set so that it has an angular advance of 28 deg. and it is desired to change the direction of rotation of the engine, how far and in what direction should the eccentric be moved to obtain the same angle of advance with the engine reversed?

J. B.

Angular advance of 28 deg. signifies that the eccentric is $90 + 28 = 118$ deg. ahead of the crank, and for opposite direction of rotation with the same angle of advance, the eccentric should be turned back 118 deg. on the other side of the crank; or, what would be the same thing, the eccentric might be turned $360 - (2 \times 118) = 124$ deg. forward in the first direction of rotation of the shaft.

Chimney Crack From Expansion of Lining—What causes a crack to form all around a brick chimney at about three-fourths of its height? The crack developed after the chimney had been in use only a short time and reappeared after it had been repointed.

A. H. W.

In construction, the core or lining has undoubtedly been incorporated with the outer walls at a point above the crack, and from expansion of the lining from heat the upper portion of the shell has been raised from the lower portion. By driving steel wedges in the crack at a time when the lining is at highest temperature the core, upon cooling, may separate itself from the shell and cause no further trouble after repointing the outside. The surest remedy would be to remove the upper portion of the stack down to a point where the lining can be stopped off and rebuild the exterior in such a manner that it will not be affected by the expansion of the lining.

Properties of Nickel Steel—How is nickel steel made, and how does its strength compare with that of simple steel?

C. S.

Nickel steel is made by adding metallic nickel, nickel ore or ferro-nickel to the bath of the openhearth process. The finished product usually contains 3 to 4 per cent. nickel, about 0.3 per cent. carbon, 0.7 per cent. manganese and 0.02 per cent. phosphorus. The presence of nickel decreases the corrosiveness and increases the density and strength of the steel. On account of its high elastic limit and toughness, nickel steel is well adapted to resistance of sudden stresses and shocks. As compared with simple steels of the same tensile strength, a 3-per cent. nickel steel has about 15 per cent. higher elastic limit and about 25 per cent. greater elongation, and as compared with simple steels of the same carbon, the nickel steel up to 5 per cent. nickel has about 40 per cent. greater tensile strength with practically the same elongation and reduction of area.

Quality of Steam by Separating Calorimeter—In using a separating calorimeter the graduated glass gage on the instrument showed that the calorimeter in a given time had collected 0.15 lb. of water, and during the same time there was 2 lb. 14 oz. of condensate of the dry steam added to the condensing water. What was the quality of the steam?

W. C. H.

Where W represents the weight of water that the calorimeter separated from the steam, and W_1 represents the weight of dry steam condensed after separation, then the total weight would be $W + W_1$ and the quality q, or dryness, would be represented by the formula,

$$q = \frac{W_1}{W + W_1}$$

As $W_1 = 2$ lb. 14 oz. $= 2\,^{14}/_{16}$, or 2.875 lb., and $W = 0.15$ lb., then by substitution,

$$q = \frac{2.875}{0.15 + 2.875} = 0.954, \text{ or about 95 per cent.}$$

Size of Pump—With 50 ft. of piston speed per minute, what diameter would be required for the piston of a pump to supply 140 gal. of water per min., allowing 7 per cent. reduction of displacement by slippage and piston rod?

C. W. O.

Allowing 231 cu.in. per gal. and for the reduction of capacity by slippage and piston rod, the required gross displacement would be

$$\frac{140 \times 100}{100 - 7} \times 231 = 34{,}774+ \text{ cu.in. per minute,}$$

which for a piston speed of 50 ft. per min. would require a piston having

$$\frac{34{,}774}{50 \times 12} = 57.95 \text{ sq.in. of area}$$

which corresponds to

$$\sqrt{\frac{57.95}{0.7854}} = 8.59,$$

or about 8½ in. diameter.

Starting Torques of Motors—How do the starting torques of series- and shunt-wound direct-current motors compare with those of squirrel-cage and wound-rotor types of alternating-current motors?

C. H. R.

The starting torque of a series motor may be several times the full-load torque, the torque increasing much more rapidly than the current or nearly as the square of the current, until magnetization approaches saturation, when it varies more nearly as the current, the maximum torque being at the minimum speed. In a shunt-wound motor the starting torque varies directly as the current and may be 2 to 2¼ times the full-load torque. In a squirrel-cage motor full-load torque requires several times the full-load current, hence this type of motor is not adapted for use where a heavy starting torque is required. A wound-rotor type induction motor will start under full-load torque with little more than full-load current, and with a high-resistance rotor the starting torque can be increased beyond the full-load torque.

Air Required for Combustion of Gas—What number of cubic feet of air is theoretically required for the combustion of a cubic foot of gas consisting of 75 per cent. CH_4, 20 per cent. C_2H_6 and 5 per cent. C_3H_8?

N. C. I.

In formation of the products CO_2 and H_2O the volumes of O_2 from the atmosphere will be required in the proportions of

$$CH_4 + 2\ (O_2) = CO_2 + 2\ H_2O,$$

0.75 of a cubic foot requiring $2 \times 0.75 = 1.5$ cu.ft. of O_2;

$$2\ C_2H_6 + 7\ (O_2) = 4\ CO_2 + 6\ H_2O,$$

0.20 of a cu.ft. requiring $^7/_2 \times 0.20 = 0.7$ cu.ft. of O_2;

and

$$C_3H_8 + 5\ (O_2) = 3\ CO_2 + 4\ H_2O,$$

0.05 of a cu.ft. requiring $5 \times 0.05 = 0.25$ cu.ft. of O_2. That is, combustion of 1 cu.ft. of the mixture requires

$$1.5 + 0.7 + 0.25 = 2.45 \text{ cu.ft. of } O_2.$$

As oxygen contained in air constitutes 20.92 per cent. of its volume, then as 4.78 cu.ft. of air will be required to furnish 1 cu.ft. of oxygen, the 2.45 cu.ft. of oxygen needed for combustion of 1 cu.ft. of gas will require $4.78 \times 2.45 = 11.71$ cu.ft. of air.

Distribution of Heat in Gas-Engine Cylinder*

By A. H. Gibson and W. J. Walker

An experimental gas engine recently installed in the engineering laboratories at University College, Dundee, appeared to afford exceptional facilities for an investigation into the cylinder losses. This engine, built by the National Gas Engine Co., Ltd., has a cylinder diameter of 11 in. and a stroke of 19 in., and the connecting-rod may be lengthened so as to vary the compression ratio between the limits 5.17 and 6.62. Governing is on the hit-and-miss principle. A special feature is the arrangement of the cylinder jacket in two parts—one surrounding the exhaust valve and that portion of the exhaust passage included within the cylinder casting, and the other covering the breech end and barrel of the cylinder. The jacket water is led in series through the two sections, its temperature being measured before and after passing through each. The heat attributed to jacket losses in a gas engine having the usual arrangement of jackets includes a certain amount which, correctively, should be attributed to exhaust losses. In the engineering under consideration the magnitude of these two sources of loss can be ascertained with much greater accuracy.

In order to measure the heat contained in the exhaust gases after leaving the cylinder, an exhaust cooler was fitted to the exhaust branch. In this cooler the temperature of the gases was reduced by their passage over a series of 33 tubes, each ⅝ in. outside diameter and 4 in. long. The jacket water passed through these tubes on its way to the cylinder jackets, and its temperature was measured before and after passing through the cooler.

The trials were carried out with a view to determine how the distribution of heat through the engine varies with the speed of the engine, the brake horsepower, the compression ratio and the richness of the mixture.

The normal speed of the engine is 200 r.p.m., but in the trials a range of speeds from 140 to 260 r.p.m. was examined. The maximum brake horsepower depends on the speed and mixture, its values being approximately as follows:

Air Ratio—(Vols.) Gas	Speed, R.p.m. 150	200	250
7	25.0	31.5	36.0
9	20.0	25.0	28.5
11	16.5	20.5	23.5

*From a paper read before the Institution of Mechanical Engineers, May 14, 1915.

In the trials the brake horsepower was varied from zero up to this full-load capacity. Three different compression ratios were adopted—5.17, 5.70 and 6.62—and three different air-gas mixtures were used—7 : 1, 9 : 1 and 11 : 1. In individual trials of the same series the richness of the mixture varied by not more than 5 per cent. on each side of the mean, and in the majority of cases the variation did not exceed 2 per cent. either side.

Town gas was used, having an average analysis of: CO_2, 3.8 per cent.; O_2, 1.1 per cent.; CO, 13.0 per cent.; CH_4, 26.3 per cent.; C_2H_4, 4.7 per cent.; H, 38.0 per cent.; N, 13.1 per cent. The gas supply was measured by a dry meter, and its mean lower calorific value, which was used in all calculations, was 520 B.t.u. per cu.ft. The air-supply was also metered.

Systematic analyses of the exhaust gases were carried out, mainly with a view to insuring that combustion was complete before the end of expansion. In no case was more than a trace of combustible found in the gas, and in the majority of cases no trace was found.

Of the total heat in the exhaust gases leaving the cylinder, part was absorbed by the water in the exhaust-valve jacket and part in the exhaust-gas cooler. The latter was not sufficiently large to cool down the gases to atmospheric temperature, and their temperature on leaving the cooler was between 200 and 300 deg. F. The heat carried away by these gases was estimated from a knowledge of their weight, specific heat and temperature.

From the data obtained, a series of curves was plotted, and by interpolation from these curves the more important data corresponding to speeds of 150, 200 and 250 r.p.m. and to brake horsepowers of 10, 15, 20, 25 and 30 were deduced for each gas mixture and for each compression. The main results of the investigation may be summarized as follows:

The mechanical efficiency increases with increasing load, diminishes as the ratio of air to gas increases (Fig. 2), diminishes as the speed increases (Fig. 3) and is sensibly independent of the compression ratio (Fig. 4). The maximum efficiency attained in these trials, namely, at full load with the richest (7 : 1) mixture and at the lowest speed (150 r.p.m.), was 88 per cent. At the normal speed of 200 r.p.m. and with the same mixture, the efficiency was 85 per cent., while with this same speed and the weakest (11:1) mixture, it fell to 76.7 per cent.

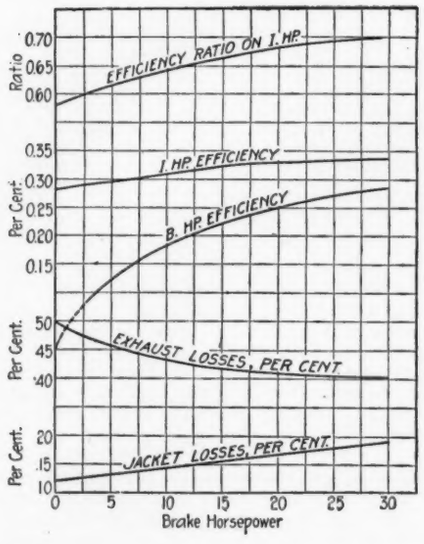


Fig. 1. Performance with a 5:17 Compression Ratio; Air: Gas = 9:1, and 200 R.P.M.

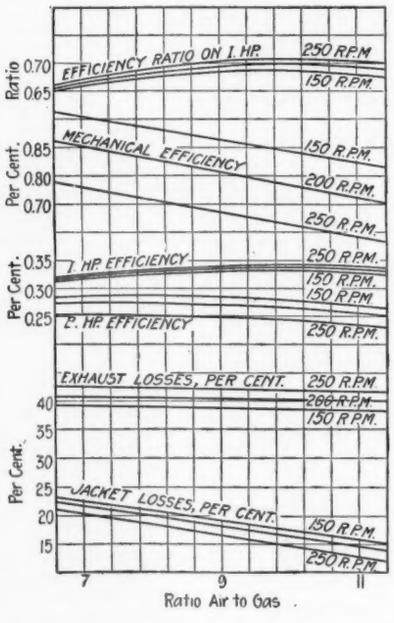


Fig. 2. Full Load with a Compression Ratio of 5:17

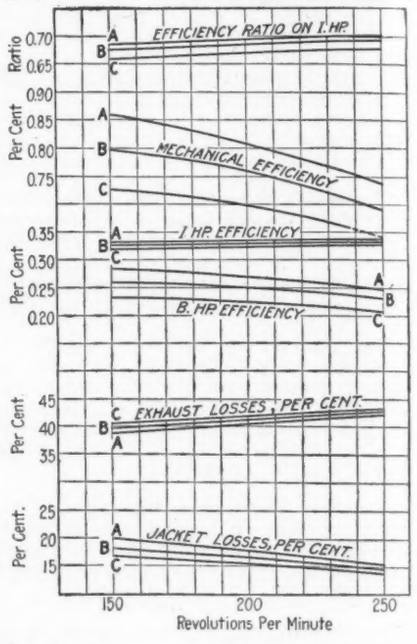


Fig. 3. Compression Ratio = 5:17; Air: Gas = 9:1. Curve A at Full Load Curve, B at .8 Load, Curve C at .6 Load

The thermal efficiency, as measured on the indicated horsepower, increases with the load (Fig. 1), attains a maximum with an air-gas mixture of approximately 10 : 1 (Fig. 2), increases slightly as the speed increases (Fig. 3), and increases as the compression ratio increases (Fig. 4). The maximum thermal efficiencies attained were as follows:

		Efficiencies		
Compression ratio		5.17	5.70	6.62
Speed	150	33.1	34.4	36.5
	200	33.9	35.3	37.4
	250	34.4	35.8	37.9

As measured on the brake horsepower, the thermal efficiency increases with the load (Fig. 1); attains a maximum with an air-gas ratio of 8 : 1, that is, with a richer mixture than gives maximum indicated efficiency (Fig. 2); diminishes as the speed increases (Fig. 3), and increases with the compression ratio (Fig. 4). The maximum efficiencies based on the brake horsepower were:

		Efficiencies		
Compression ratio		5.17	5.70	6.62
Speed	150	27.9	29.1	31.0
	200	27.5	28.6	30.2
	250	25.7	26.7	28.3

Adopting the air cycle as the standard of comparison, the ideal efficiencies corresponding to the various compression ratios were:

Compression ratio	5.17	5.70	6.62
Air cycle efficiency	0.482	0.501	0.532

The ratio of the actual thermal efficiency, measured on the indicated horsepower to the corresponding air-cycle efficiency, increases with the load (Fig. 1), has a maximum value when the ratio of air to gas is approximately 10 : 1 (Fig. 2), increases slightly with the speed (Fig. 3), and is sensibly independent of the compression ratio (Fig. 4). At full load and with the most efficient air-gas mixture, the relative efficiencies were, for all compressions:

Revolutions	150	200	250
Efficiency ratio	0.687	0.700	0.709

The exhaust losses, in per cent., diminish as the load increases (Fig. 1), diminish very slightly as the ratio of air to gas increases (Fig. 2), increase as the speed increases (Fig. 3), and diminish as the compression ratio increases (Fig. 4). At full load the exhaust losses in these trials were between 33.6 and 42.5 per cent. The former value corresponds to a weak mixture, high compression and low speed, and the latter to a rich mixture, low compression ratio and high speed.

The percentage of heat carried away by the water flowing through the cylinder jackets, not including the exhaust-valve jacket, increases with the load (Fig. 1), diminishes as the ratio of air to gas increases (Fig. 2), diminishes as the speed increases (Fig. 3), and is sensibly independent of the compression ratio (Fig. 4).

Since at 150 r.p.m. the period of contact per cycle, of hot gases and cylinder walls, is 1.66 times as great as at 250 r.p.m., the rate of heat transmission through the cooling surfaces is evidently much greater at the highest speed. An examination of the indicator diagrams, moreover, shows that the maximum pressure and temperature attained in the cylinder are approximately 6 per cent. greater at 150 than at 250 r.p.m., so that this increased rate of transmission is obtained in spite of a lower gas temperature. The reason is apparently to be found in the fact that the greater turbulence of the working fluid at the higher rates of speed increases its effective conductivity to an extent which more than counterbalances the effects of a smaller temperature difference and a shortened time of contact. Other things being equal, a 6-per cent. increase in the temperature of the gases would probably increase the heat transmitted by conduction and radiation by some 15 per cent., so that it may be taken approximately that the effective conductivity is increased in the same ratio as the speed of the engine.

The radiation loss diminishes as the load increases, increases as the ratio of air to gas increases, diminishes as the speed increases, and increases slightly as the compression ratio increases. At full load, radiation accounts for between 5 and 14 per cent. of the heat given to the engine, the former value obtaining with a rich mixture, high speed and low compression ratio and the latter with a weak mixture, low speed and high compression ratio.

DISTRIBUTION OF HEAT UP TO END OF EXPANSION STROKE

Since part of the heat carried away by the jacket water passes into the cylinder walls after release, this should, in a true heat balance, be credited to the exhaust. The item attributed to radiation represents heat lost by radiation from the hot exposed surfaces of the piston and of the unjacketed portion of the breech, and from the outer surface of the jackets. Although this loss is wholly due to heat flow through the walls, only part of this flow takes place during the expansion stroke. The remainder, occurring after the end of this stroke, is also to be attributed to the exhaust.

Thus in a heat balance drawn for the working fluid up to the end of expansion, the apparent heat flow into the walls is to be increased by the greater part of this radiation loss and to be diminished by that part of the heat transmitted to the jacket water during exhaust. Similarly, the apparent exhaust losses are to be increased by some small part of the radiation loss and by that part of the heat given to the jacket water during exhaust. The net result is that both the wall losses and the exhaust losses, as given by direct measurement, are to be increased by some unknown proportion of the radiation loss.

The results indicate, in general, that of the total radiation loss obtained by difference from the heat measurements a proportion ranging from about 0.33 to 0.40 is to be added to the apparent exhaust losses, the remainder going to increase the apparent jacket or wall losses. This proportion reaches its highest value with the highest compression ratios and with the richest mixtures.

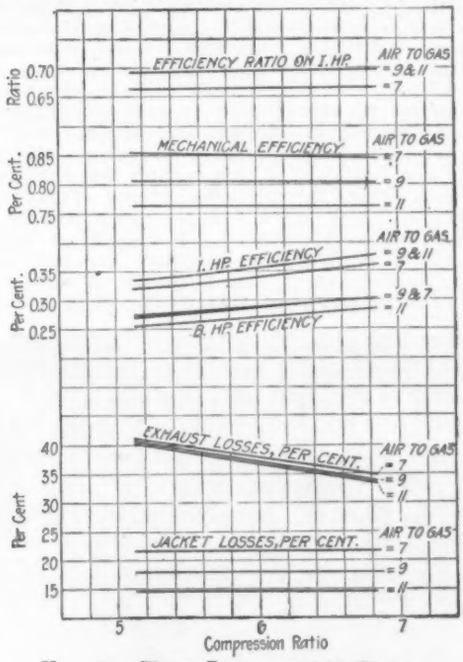


FIG. 4. FULL LOAD AT 200 R.P.M.

A comparison of these with results obtained in a similar manner by Hopkinson on a slightly larger engine, shows a fairly close agreement. In round numbers the figures are as follows:

	$\frac{\text{Air}}{\text{Gas}} = 10.8$		$\frac{\text{Air}}{\text{Gas}} = 8.1$	
	Hopkinson	Authors	Hopkinson	Authors
Heat as i.hp.	37	36	33	35
Heat in exhaust	42	41	39	39
Heat flow to walls	21	23	28	26

The heat entering the exhaust-valve jacket ranges from 8 to 12.5 per cent., being the greatest at low loads, low speeds and with low compression ratios and rich mixtures. If this be added to the cylinder-jacket loss, it gives the loss as determined from trials of an engine fitted with the usual arrangement of jackets.

Under favorable circumstances it appears that a heat balance sheet obtained by measuring the indicated work and jacket heat of a commercial type of engine, and by estimating exhaust losses by difference, is in extremely close agreement with the balance sheet based on the internal energy of the gas at the end of expansion. For fairly rich mixtures and lower compression ratios the measured jacket losses are, however, always in excess of those more correctly computed from the internal energy of the gas.

Hydrogen Was Discovered or isolated in 1766 by Cavendish, an eccentric English chemist, who called it "inflammable air," but the French chemist, Lavoisier, named it hydrogen, meaning "water former." Nitrogen was also identified as a constituent of air at about the same date as oxygen and hydrogen (1766 to 1774) and named nitrogen by Chaptal, because of its existence in niter.

Illinois N. A. S. E. State Convention

The eleventh annual meeting of the Illinois State Association, N. A. S. E., held in Decatur, May 26-28, proved to be one of the best in the history of the organization. Business was attended to promptly by the engineers, exhibits were good, and the entertainment was lively from beginning to end. Good fellowship prevailed and the close coöperation between the engineers and the exhibitors contributed largely to the success of the convention. The first session opened promptly Wednesday morning at the St. Nicholas Hotel, with W. H. Jennings, chairman of the local committee, presiding. After the opening prayer by Rev. C. E. Jenney, Mayor Dan Dinneen made an address of welcome, to which Fred W. Raven, national secretary, responded.

Dr. G. E. Fellows, president of Millikin University, of Decatur, in an interesting address on education, referred briefly to the educational work of the organization, and then turned to the broader aspect of his subject and showed how education was correlated with the advancement made by the human race. Up to 150 years ago the people thought that they needed a king to do their thinking for them and tell them what they must do. France was the first country to give the people the opportunity to rule themselves and to allow them freedom of thought and action. Most of the advancement made has been since that time. The greatest thing that ever happened to this country was the act signed by Abraham Lincoln setting aside grants of lands in the various states, which made possible the state universities and provided higher education for the people at large. For the past thirty years serious attention has been given to industrial education, and during this time more progress has been made than in all the previous years. It is evident, then, that progress and advancement are largely dependent on education.

In his response, John Lane, editor of the "National Engineer," contended that it was a general mistake to confound education with teaching. Schools teach men, but they must educate themselves. If they cannot retain or apply what they have learned, then the teaching is useless. The man who can apply what he does know to the best advantage, whether learned in college or in practice, will make the most progress and be of the most use to the community.

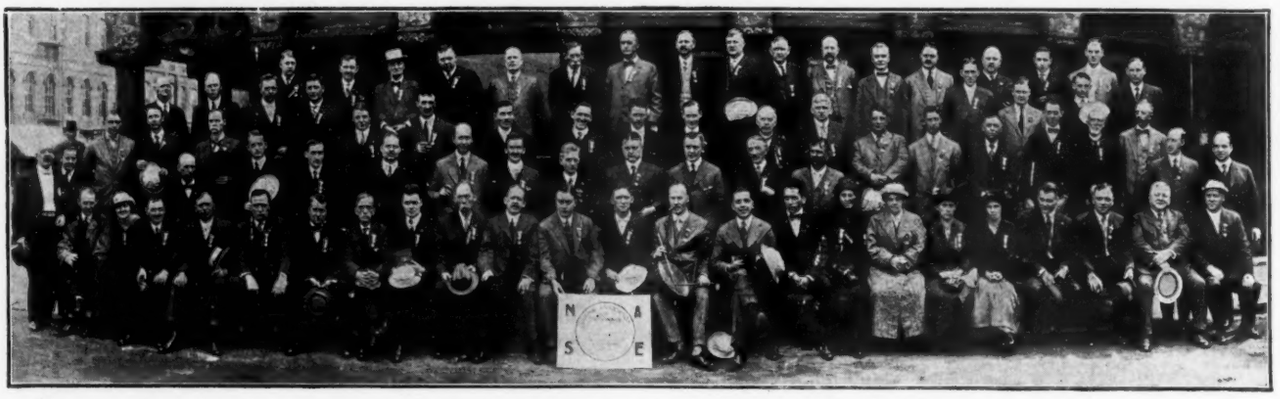
After a brief talk by Charles Cullen, president of the Central States Exhibitor's Association, W. E. Hill, state president, was formally introduced and the meeting was officially opened. The usual committees were appointed and the session adjourned.

The afternoon was spent in a trip to the Wabash locomotive shops. A large number of engines were being overhauled, and the work proved to be of exceptional interest. For the benefit of the visitors a locomotive weighing 78 tons was raised from the floor, moved a distance of 50 ft. and lowered upon the wheels placed for it, in five minutes. The placing of the engine was so accurate that it was not necessary to move it to the right or the left as it was lowered in position.

In the evening State Deputy Henry Misostow delivered an address at a special meeting of exhibitors and engineers. His topic was "Efficiency," of which there were two kinds, one sensible and the other commercial. The former created more for the same expenditure of energy. Employees were treated as men and encouraged to use their brains in performing their duties. In the other system men were made into machines and their efficiency based on the amount of their work. There should be no distinct demarcation between engineers. Any engineer can be as good as any other provided he puts as much energy into his work and puts forth the same amount of effort to become efficient. Many men look at the man above them admiringly and think, "He is better than I." This admission should never be made until the same effort has been exerted to become efficient. At the close of the address Messrs. Hickey, Tilley, Thompson, Fiske, and the famous quartet gave an excellent and thoroughly enjoyable performance.

At the business session Thursday morning there were 32 accredited delegates from 13 associations out of 17 belonging to the state organization. In his report President Hill stated that two new locals had been added in the past year and one of these had joined the state association. The president spoke highly of the work of the educational committee. Secretary Anderson reported a net gain of 43 members, which was a little over 3 per cent. of the total number affiliated with the state body. John S. Alt, chairman of the legislative committee, reported that license and inspection laws similar to those in force in Massachusetts and Ohio had been presented to the state legislature, and by compromising on the boiler pressure and the square feet of radiation requiring a licensed engineer, it was thought that the chances were excellent for the bill to pass at the present sitting of the legislature. The compromises thought necessary were to raise the boiler pressure from 10 to 20 lb. and to increase the radiation from 5000 to 20,000 sq.ft.

In the afternoon the engineers were taken through the Decatur High School and shown the annual exhibit of the pupils. In the auditorium of the school they listened to an interesting lecture by Prof. G. E. Goodenough, of the University of Illinois, on the development of the steam tables and on the properties of saturated and superheated steam. The professor gave briefly the leading events in the development of the steam tables, reviewing the work of Regnault, Callendar, Knoblauch and Linde, Davis, Peake and Grindley and other authorities who had contributed to the work. By means of charts he compared the results obtained by these various experimenters and calculators. He commented on the accuracy of their work and in curve form presented the results obtained from a formula he had developed after a careful consideration of all the data that had been previously given on the subject.



DELEGATES AT ILLINOIS N. A. S. E. STATE CONVENTION

In the evening delegates and visitors were entertained at the exhibitors' hall, with a theater party sandwiched in between. The ball game scheduled between the engineers and supplymen for Friday morning was called off on account of rain. At the last session on Friday afternoon, Henry Mistele, of Milwaukee, one of the national trustees, talked on the good of the order, referring particularly to education and the most effective medium for education the association possessed—"The National Engineer." He asked the engineers to support their paper and spoke of the value of the advertising section. Peoria was chosen as the next convention city, and the following officers were elected: Henry Misostow, state president; Charles Scott, vice-president; G. R. Anderson, secretary-treasurer; W. E. Hill, state deputy. "Dad" Beckerleg installed the officers, and the convention adjourned for another year.

The exhibits were up to the usual standard, the following firms being represented: The V. D. Anderson Co., Crandall Packing Co., Dearborn Chemical Co., Edward Valve & Manufacturing Co., Greene, Tweed & Co., Hawk-Eye Compound Co., Garlock Packing Co., Home Rubber Co., Jenkins Bros., H. W. Johns-Manville Co., Keystone Lubricating Co., Lunkenheimer Co., "National Engineer," Peerless Rubber & Manufacturing Co., Wm. Powell Co., "Power," Madison-Kipp Lubricator Co., H. Mueller Manufacturing Co., National Boiler Specialties Co., Perolin Co. of America, The Screiber Perfect Boiler Skimmer & Cleaner Manufacturing Co., Standard Oil Co.

Mechanical Stokers for Locomotives

Before the seventh annual convention of the International Railway Fuel Association, held in Chicago, May 17-20, the committee on firing practice, D. C. Buell, chairman, presented an interesting report on mechanical stokers as applied to locomotives. A brief summary follows:

The original conception of a mechanical stoker for locomotives contemplated the adoption of the stoker on a fuel-economy basis. The claims were based on the fact that the stoker supplied coal to the fire uniformly and according to the single-scoop method; that it overcame the necessity of opening the fire-door and the consequent cooling effect in the firebox and that it avoided the production of black smoke. The introduction of larger and heavier power, together with the desire to work this power to maximum capacity on low-grade lines where continuous firing is necessary, has brought about a new problem. The amount of coal necessary to burn per hour to keep these locomotives working at full capacity is such that there has been a demand for two firemen on all locomotives weighing over 185,000 lb. on the drivers.

The real economy of the stoker is in the increased tonnage that can be handled by stoker-fired locomotives—not in the saving of fuel, as seems to be the general impression. The large, mechanically fired locomotives are able to handle more tonnage than the same locomotives would be given if hand-fired, and they handle this tonnage at a higher speed and with greater certainty than under hand-firing conditions. The development of the stoker has made possible the development of locomotives designed to burn coal continuously at a rate in excess of the capacity of the ordinary fireman to supply it, so that the real reason for the improvement and adoption of the mechanical stoker is found in the economic necessity of reduced operating costs. Other causes giving an incentive to stoker development are the possibility of increasing the capacity of locomotives already in service and the possibility of using cheaper fuel on such locomotives.

There are three companies now manufacturing locomotive stokers commercially; and in addition, the Pennsylvania Lines West of Pittsburgh have developed the Crawford stoker and applied it extensively to their own locomotives. According to the most reliable figures obtainable on Apr. 1, 1915, there are 935 locomotives equipped with stokers, which are distributed between twenty different lines of railroad.

There seems to be no fixed factor that can be used as a sure guide as to the size of the locomotive that would warrant the installation of a stoker. One report indicates that any locomotive of 200,000 lb. total engine weight, with cylinders of 22 in. or over should be equipped with a stoker. A second report states that engines having a tractive effort of 50,000 lb. or over, should be stoker-fired. It seems to be the consensus of opinion, however, that locomotives should be hand-fired when the coal consumption for an extended period does not exceed 4000 lb. per hr. It is the general belief that the stoker will give about 10 per cent. increased tonnage capacity as compared with hand-firing under the same conditions as to grade and time, although some reports indicate that the tonnage increase will be more. Stoker-fired engines will make better time with the same tonnage on the same grade than hand-fired engines, and there will be a saving on the basis of the amount of coal burned per thousand ton-miles. This is due to the fact that additional tonnage may be handled by stoker-fired engines with about the same gross amount of coal as with hand-fired engines.

The meat of the whole stoker problem is, that increased tonnage can be handled. If increased capacity of locomotives is desired, then stokers are economical. If maximum evaporation is what is required on large engines, its attainment may result in a sacrifice of tonnage capacity. A number of other advantages were given, such as reduction of smoke and spark loss. The first cost of the stoker installation is between $1500 and $1700. Maintenance cost, including interest on the original investment, is anywhere from ½ to 1c. per mile. This item is more than counterbalanced if a cheap grade of fuel is used with the stoker.

Briefly summarized, the results of the use of locomotive stokers are as follows: The stoker is over 90 per cent. efficient. A six months' record of the use of stokers on the Norfolk & Western R.R. shows an efficiency of 97½ per cent. Roads having a considerable number of stokers in service show a performance of over 50,000 miles per engine failure on stoker-fired locomotives. It seems conservative to state that the stoker will show a satisfactory fuel economy based on ton-mile performance; that is, while it may not show a reduction in the gross amount of coal consumed per trip, it will show that it can haul more tonnage, using about the same gross quantity of the same or a cheaper grade of fuel, than a hand-fired engine. From the coal producer's standpoint, the increased demand for slack coal and screenings for stoker-fired engines will be of benefit. The stoker obviates the necessity for two firemen on large engines. No complications are introduced in the way of detention at terminals, engine failures on the road, or in connection with the smoke-elimination problem. To sum up, the stoker, even in its present state of development, pays in every case where real stoker jobs are indicated.

Looking into the future, the development of the stoker makes possible and practical the design of larger locomotives. In fact, engines have been purchased within the last two years and are being built today which would neither have been purchased nor built had it been necessary to have them hand-fired. Particular reference is made here to the large decapod, mallet and triplex engines. So far, manufacturers have been compelled to adapt their stokers to existing locomotives. It is safe to say that in the future the design of large locomotives will contemplate the application of a stoker, and the design will be modified as may appear necessary to insure convenient, economical and successful application of correspondingly modified and improved stokers.

Central-Station Conditions

The general conditions of the central-station industry are reviewed by T. C. Martin, in his annual report on progress to the National Electric Light Association. While the industry has suffered to some extent by the general business depression, and has not maintained the normal rate of increase, still the outlook is encouraging. Figures from 65 per cent. of the companies indicate that for the second half of 1914 there was an increase in earnings of at least 5 per cent. The combined operating revenue of the Brooklyn system, for example, showed a gain for 1914 of 10.5 per cent.; the gross earnings of the Providence system increased 9.25 per cent. over the preceding year, and new business showed a gain of 18.7 per cent. The Pacific Gas & Electric Co.'s gross earnings for 1914 were about a million dollars greater than in 1913, and the Detroit-Edison system showed a gain of 11.1 per cent. The gross earnings of the central-station industry as a whole in 1914 are estimated in excess of 375 million dollars. This is in addition to the lighting and power work done by street-railway systems.

The yearly peaks and load factors of the leading systems for 1914 were as follows:

System	Peak Load in Kw.	Date of Peak Load	Yearly Output in Kw.-Hr.	Yearly Load Factor Per Cent.
Niagara Falls Power Co.	131,520	Jan. 5	906,513,620	78.7
Ontario Power Co.	130,500	Sept. 23	781,664,400	68.4
New York Edison Co.	229,787	Dec. 23	719,193,535	35.7
Pacific Gas & Electric Co.	124,000	Oct. 29	658,298,000	60.6
Penn. Water & Power Co.	74,000	Dec. 17	277,200,000	42.5
Philadelphia Electric Co.	77,728	Dec. 1	250,697,952	36.8
Boston Edison Co.	65,342	Dec. 21	194,137,400	34
Brooklyn Edison Co.	49,300	Dec. 9	153,946,900	35.6
Commonwealth Edison Co.	306,200	Dec. 15	1,114,130,000	43.6

Apparently, the diversity of the loads along the Atlantic seaboard did not vary greatly, since the annual load factors of the Boston, New York, Brooklyn and Philadelphia companies are not far apart. The Pacific Gas & Electric Co., however, with its greater territory and greater diversity of load, shows a much higher load factor, as do also the Ontario Power Co. and the Niagara Falls Power Co.

OBITUARY

Samuel C. Midlam died on June 2 at the age of 83 in New York. He served in the navy during the Civil War, was chief engineer of the old United States Man-of-War "Otsego" when that vessel was sunk in Albermarle Sound, and also served on the old "Atlanta" and the gunboat "De Soto." After his retirement from the navy, nearly thirty years ago, he entered the service of the Hudson River Day Line. When he retired last year as chief engineer of the Day Line steamer "Albany," he was said to be the oldest engineer in the United States, in point of age as well as service.

Hydro-Electric Plants in New England are producing more than 2,000,000,000 kw.-hr. of energy, which, if produced by coal, would mean the annual consumption of 3,000,000 tons of that fuel, according to figures given by Henry I. Harriman, president of the Connecticut River Power Co., in an article in the "General Electric Review."

PERSONALS

E. A. Thompson has resigned as smoke inspector of the City of Baltimore and will take up consulting and efficiency engineering, with offices at the Hansa House, Charles and German Sts., Baltimore.

Myron J. Bigelow, formerly mechanical engineer with the Molyneux Mailing Machine Co., Buffalo, N. Y., has opened a consulting engineering office, with headquarters at 47 Hawthorne St., Akron, Ohio.

ENGINEERING AFFAIRS

The American Boiler Manufacturers' Association will hold its annual convention at the Lawrence Hotel, Erie, Penn., June 21-23. One of the most important matters to be considered is the means of securing the adoption of the A. S. M. E. Boiler Code by the several states. J. D. Farasey, East 37th St. and Erie R.R., Cleveland, Ohio, is secretary.

The National Association of Master Steam and Hot Water Fitters will hold its twenty-seventh annual convention June 21-24, at the Hotel Wisconsin, Milwaukee. An attractive program has been arranged, and the coöperation and active support of all members are requested to make this the most successful convention in the association's history.

The American Supply and Machinery Manufacturers' Association held its annual convention at the Bellevue-Stratford, in Philadelphia, June 3 and 4. A number of excellent addresses were made on topics vitally concerning the business of the members, notably an address on "The Power Problem," by C. M. Ripley, and an address on "Fundamental Business Conditions," by P. F. Bryant, of Wellesley Hills, Mass. The entertainment features included a vaudeville-smoker and a dinner-dance.

The New England Association of Commercial Engineers, 308 Equitable Building, Boston, Mass., has selected the new building now under construction at the corner of Oliver and Franklin St., and will use the basement and first two floors as an exhibit, while the upper floors will be used for a meeting room and lecture hall for the several engineering organizations and mechanical societies and for offices. It is thought that the whole building will be occupied by those interested in the machinery and power-equipment field. It is expected that the exhibit will be opened on Oct. 1 in the new building. Mr. Lewis L. Warren is manager of the exhibit.

The American Iron & Steel Institute held its eighth general meeting on May 28 at New York. The following papers were presented: "Blast Furnace Advancement," by Andrew E. Maccoun, superintendent, Edgar Thomson Blast Furnaces, Carnegie Steel Co., Braddock, Penn.; "Merchant Rolling Mills," by Jerome R. George, chief engineer, Morgan Construction Co., Worcester, Mass.: "The Commercial Production of Sound and Homogeneous Steel," by Edward F. Kenney, metallurgical engineer, Cambria Steel Co., Johnstown, Penn.; "Waste-Heat Boilers," by Charles J. Bacon, steam engineer, Illinois Steel Co., South Chicago, Ill.; and "Recent Progress in Corrosion Resistance," by Daniel M. Buck, metallurgical engineer, American Sheet & Tin Plate Co., Pittsburgh, Penn.

The National Association of Manufacturers held its annual meeting May 25 and 26 at New York. The sessions were devoted mainly to legal and economic questions. The convention adopted the report of the Committee on Fire Prevention, stating that full coöperation between state legislators, insurance companies and property owners, and the spending of more money by municipalities and legislatures for fire prevention were the best means for reducing the enormous waste of the nation's resources. The convention, through the Committee on Accident Prevention and Workmen's Compensation, held that mechanical safety devices can prevent but a small percentage of accidents, while the large majority must be prevented by education, organization and individual caution, with emphasis upon individual caution. The Industrial Betterment Committee rendered a preliminary report on the legislative minimum wage, concluding that such legislation was not wanted by employees or employers and had been unsatisfactory to both, and that undesirable industrial conditions could best be improved through practical education and by stricter legal supervision.

BUSINESS ITEMS

The Homestead Valve Manufacturing Co., Desk D, Pittsburgh, Penn., is conducting a prize name contest, offering $50 cash as a prize for a suitable name for a new gate valve.

E. W. Swartwout, formerly of the Chicago office of the Nordberg Manufacturing Co., Milwaukee, Wis., will hereafter be associated with Mr. McLaren, in the New York office of the company. Enlarged offices have recently been taken in the new Equitable Building, 120 Broadway, New York. The Chicago office will be in charge of John E. Lord.

James Beggs & Co., manufacturers of the Blackburn-Smith feed-water filter and grease extractor and the Beggs sewage ejector system, have opened offices in Saginaw, Mich., and Cleveland, Ohio. Their representatives at these points will give prompt attention to inquiries received from the State of Michigan and the northern part of the State of Ohio, respectively.

The "S-C" Regulator Co., Fostoria, Ohio, has established the following branch offices: Chicago, Ill., 1535 Lytton Building, in charge of L. K. Deckerson and E. H. Bolton; New Orleans, La., 315 Carondelet St., George Keller; Atlanta, Ga., 702 Candler Building, E. F. Scott; Charlotte, N. C., 1213 Realty Building, James E. Weinhold. In Birmingham, Ala., the company will be represented by the McClary-Jemison Machinery Co.

The Berwind-White Coal Mining Company, Windber, Penn., recently ordered twenty-six 2½-in. Simplex "Seatless" blow-off valves from the Yarnall Waring Co., Chestnut Hill, Philadelphia, Penn. The interesting feature of this order is that it makes the fifth repeat order as a result of a six-months' trial of two valves shipped Feb. 11, 1914. The Corrigan-McKinney Co., Cleveland, Ohio, has recently ordered 56 of these 2½-in. valves.

The Terry Steam Turbine Co., Hartford, Conn., has appointed Merton A. Pocock as district sales manager for the territory included in Minnesota, North Dakota and South Dakota. His office is 400 Endicott Building, St. Paul, and this arrangement supersedes the company's previous selling agreement with Robinson, Cary & Sands Co., of St. Paul. The company has also appointed the Hawkins-Hamilton Co., Peoples National Bank Building, Lynchburg, Va., as representatives for Virginia.

The Diesel-type engine manufactured by the McIntosh & Seymour Corporation, of Auburn, New York, will in future be sold in the Texas and Oklahoma territory through the agency of Arthur G. Wright, 209 Slaughter Building, Dallas, Texas. This appointment excludes that portion of Texas west of a line drawn north and south through Del Rio. Mr. Wright's extensive experience with the machinery business and particularly with all types of power plants, renders him a valuable consultant to those who are considering new installations, and his advice may be sought by all interested parties.

Among the orders recently received for Venturi meters by the Builders Iron Foundry, Providence, R. I., are the following: H. C. Frick Coke Co., Pittsburgh, Penn., three 4-in. meter tubes with Type M register-indicator-recorders; Union Bag & Paper Co., Woolworth Building, New York City, one 4-in. meter tube with Type M register-indicator-recorder; John B. Mallers, Chicago, Ill., one 3-in. meter tube with Type M register-indicator-recorder. All these meters are for boiler-feed service. The West India Management & Consultation Co., 129 Front St., New York City, has ordered for the Trinidad Sugar Co. two 2½-in. meter tubes and Type M register-indicator-recorders for the measurement of maceration water. The company has also received two orders for meter tubes for the measurement of air—one from the Combination Engine & Compressor Co., Bradford, Penn., for a 2-in. meter tube and manometer to be used in the testing of air compressors, and one from Purdue University, Lafayette, Ind., for a 4-in. meter tube.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance

Positions Open, (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Opportunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books), **For Sale,** 5 cents a word, minimum charge, $1.00 an insertion.

Count three words for keyed address care of New York; four for Chicago Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A.M. Tuesday for ensuing week's issue Answers addressed to our care, Tenth Ave. at Thirty-sixth Street, New York or 1144 Monadnock Block, Chicago will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. P-

POSITIONS OPEN

A CAPABLE SALESMAN for power-plant apparatus; must be posted on boilers, pumps, heaters, and power-plant accessories in general; must be man of good address, and be capable of managing branch office in Chicago; must also be well and favorably known to the prominent consulting engineers in Chicago district, as well as the users of power-plant apparatus; an engineering graduate preferred; state age, education, engineering and selling experience, references and salary expected; an exceptional opportunity for the right man; replies will be treated confidentially. P. 531, Power.